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More on Herons

Wildlife specialists Jean and Richard Graber are presently analyzing data on Illinois herons, including a survey begun in 1973 of major colonies of the two largest Illinois species — the great blue heron and the great egret. As reported earlier, the available historical data strongly suggested that breeding populations of these two species were declining in Illinois. Other possible interpretations were that the colonies were moving about or that the populations were fluctuating up and down (as natural populations do), and that the data for recent years happened to represent low years.

That possibility still exists, but the knowledge gained from extensive air and ground searches of much of the state's suitable habitat for herons is not reassuring. Few new colonies have been found to make up for colonies lost. Although some colonies show the expected pattern of annual gains and losses, the over-all state population shows a progressive yearly decline of between 12 and 18 percent from 1973 to 1977 for the great blue heron and an average annual loss of 25 percent for

Fig. 1. The Great Blue Heron. (Photo by former Survey biologist George Bennett)

the egret, including a 55 percent loss between 1975 and 1976. The situation appears very serious and calls for special measures of protection.

Recoveries of great blue herons banded in Illinois (especially those banded by Karl Bartel of Blue Island) show the high cost to great blues of unwariness. About two-thirds of the fledged young are lost in the first year, most in the first six months, after which their chances of survival improve. The most common cause of death cited is shooting. In earlier years, the population could apparently sustain such losses and survive, but this is not true now, and hunters should be apprised of the harm being done. Unfortunately, the problem extends all the way to Central America, where some Illinois-raised great blue herons winter. We do not know whether mortality from illegal shooting is increasing, but even at the rate the herons have been killed in the past, it would take a productivity rate of about 2.8 young per adult pair to sustain the population. The *very best* average of young per nest observed by the Grabers was 2.5 young, not counting nests that failed completely.

Better information is needed on production of young and on the entire nesting cycle; however, one cannot study a colony without disturbing it, and disturbance increases food loss to young and perhaps nestling mortality. Yet, without such studies, we cannot hope to learn how to preserve the populations. Careful studies by responsible students should be encouraged, and every effort should be made to reduce human traffic in the vicinity of colonies, roosts, and the heron fisheries. The fisheries are generally located within six miles of the colony, often within a mile, and need to be protected as rigidly as the colony site itself, preferably closed to human traffic from March to September.

The question of whether the heron's problems are related to pollution has received little attention. Because great blue herons nest so high, gaining access to their nests involves great disturbance to the colony. Thus, there are no data on hatching success as a possible clue to pesticide intoxication, and no historical perspective on hatching and fledging rates from which to judge whether these rates are changing. At present the knowledge, if it is obtained, may come too late. Although herons comprise a tiny fraction of the Illinois fauna, for most groups of organisms we do not even know whether the population is changing, let alone why.

The Sam A. Parr Fisheries Research Center

The INHS field station near Kinmundy is one of the many fruitful results of a lifespan of friendship and cooperation between Sam A. Parr and George W. Bennett. Sam was for many years the Assistant Director and chief mover and shaker in the Illinois Department of Conservation, and George was the distinguished Head of the Section of Aquatic Biology in the INHS from November, 1943 until his retirement in January, 1974. Both are now deceased and have become legendary figures in conservation circles in Illinois. The station was established in 1963 as the Marion County Fisheries Research Center. Following Sam's death in November, 1966, George officially dedicated the station as the Sam A. Parr Fisheries Research Center in recognition of Sam's many contributions to the sportsmen of Illinois, and because of his long friendship with the Survey.

The Station sits as an adjunct to the Stephen A. Forbes State Park in order to tap the park's 237-ha reservoir as a water supply for the experimental ponds. Original construction included 9 drainable 1-acre ponds completed in 1963. Five additional smaller ponds were added in 1965. Original station personnel included Homer Buck, Charles F. Thoits, III, and Russell Rose. Thoits left the Survey in 1969 and was replaced by R. J. Baur. The small original staff shared the office of the park ranger in 1964-1965 and later occupied a renovated chicken house until the present quarters were completed in the spring of 1967. The present laboratory comprises about 2,700 square feet, containing an office, fish lab, limnological lab, dark room, large tank room, and a combination library and conference room. Additional fa-

cilities include two storage and service buildings and an outdoor array of 3-meter diameter experimental pools.

The first major project at this new station was to assess the time-honored but untested concept that individual ponds will have inherent productive potentials that will cause them to rank high, low or intermediate on a rather permanent basis. The 4-year study revealed a startling and previously unconceived range of variations, not only from pond to contiguous pond, but by individual ponds in consecutive years. The conclusion was that whether a pond ranked high or low in a particular year was largely due to chance. The major element of chance was believed to be the differences in rates at which, or pathways by which, available nutrients were cycled through the systems. The published results brought the authors an award for the most significant paper published in the Transactions of the American Fisheries Society in the year 1970.

Because of the surge of interest in channel catfish farming, a series of studies were initiated in 1968 to evaluate the potential and problems surrounding the production and/or management of the channel catfish in Illinois, and the interrelationships with such associated species as largemouth bass, bluegills, and golden shiners. Experiments were conducted in pools, ponds, cages and raceways, and the results have been published.

In 1972 a series of studies were initiated to compare the life histories and productivities of the largemouth and smallmouth basses, first as single species, later in association with bluegill, channel catfish and grass carp. Specific evaluations also were made of the influence of both the bluegill and the grass carp on bass production, and of the efficiency of the grass carp as a biological control of aquatic weeds. Additional projects now in progress involve (1) the production of sport fishes in ponds enriched with swine manure, and (2) the use of Chinese carps in the recycling of organic wastes. The studies are yielding useful information in such critical areas as waste management, water quality control, and the production of protein.

New Aquatic Fungi

It is difficult to characterize an aquatic fungus or even define the aquatic environment itself. Nearly any fungus that can be grown in submerged shake culture is potentially aquatic. Furthermore, there are micro-aquatic habitats such as the aqueous phase between soil particles, slime fluxes of trees, nectaries of flowers, and films of sugar solution on the surface of ripe fruit each of which has a fungal flora. The work of Survey botanist, J. Leland Crane, is presently limited to large volumes of fresh water such as swamps, streams, rivers, ponds, and lakes, and an aquatic fungus is regarded as any fungus that is normally completely submerged in these habitats for some period of its life cycle.

Aquatic Ascomycetes are abundant in freshwaters, their richest source being submerged, dead stalks of reed swamp plants and submerged wood in the form of waterlogged sticks of various kinds of trees. This submerged aquatic Ascomycete flora is large and poorly known, and many species remain to be described. There is also a large flora of the asexual stages of fungi such as aquatic Hyphomycetes found growing on submerged decaying leaves and twigs of broad-leaved trees and shrubs in well-aerated water or aquatic Sphaeropsidales which are also not uncommon on submerged, dead, reed swamp plants. The taxonomy of both these groups is in need of careful study.

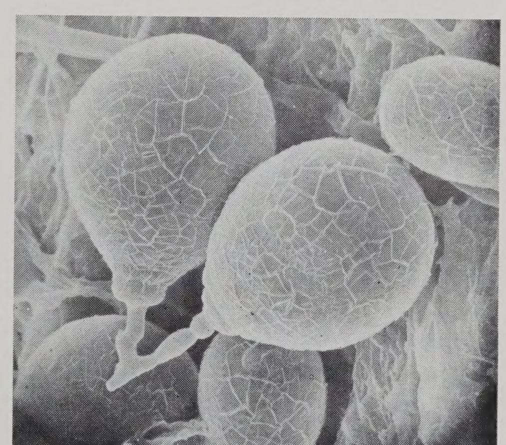

Fig. 2. Scanning electron micrograph of *Trichocladium* on submerged balsa wood (X1,020). (Photo by J. Leland Crane)

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Recently, in research leading to the identification of the fungi encountered in these aquatic habitats, Lee Crane found a new species belonging to the genus *Trichocladium* Harz. This species was collected from a cypress swamp in southern Illinois containing large quantities of decaying vegetation consisting mostly of submerged and floating aquatic plants and litter from cypress and tupelo trees. The swamp becomes extremely anaerobic in the summer and in the winter when it is covered with ice. However, oxygen concentrations are high in the spring due to photosynthesis of aquatic flowering plants and algae before light is limited by leafing-out of the canopy of trees. The new species of *Trichocladium* is characterized by solitary or aggregated conidia with 3-4 septa that are of two distinct morphological types. This *Trichocladium* species is marked by the reticulate ridges on the surface of the spores as in the figure.

The fungi of aquatic habitats is so poorly known because mycologists have traditionally devoted most of their time to the study of terrestrial fungi. In recent years, aquatic fungi have received increased attention largely due to man's concern with environmental aspects of aquatic ecology. Pollution of our streams, rivers, and lakes is common; therefore, knowledge of the kinds, frequency, distribution, and role of aquatic fungi in these situations is important.

Custom Spray Operator's School

The Thirtieth Custom Spray Operator's Training School was held January 3-5, 1978, at the University of Illinois. The Ground Sprayer's Association and Aerial Applicator's Association held a program January 3 at the Ramada Inn, Champaign, directed at those persons in custom pesticide application. The formal program was held at the Illini Union on January 4 and 5. Speakers from the University of Illinois, and several invited speakers from outside the University, presented talks on the many facets of agricultural pesticides.

The Custom Spray School began in 1949, the brainchild of H. B. Petty, then Extension Entomologist. Even at that early date it addressed problems in application, safety, laws and regulations, and effective pest control. Attendance has grown steadily over the years to a record of 1,705 in 1977. Now under the leadership of Steve Moore, Extension Entomologist at the University of Illinois and the Illinois Natural History Survey, the Custom Spray School has become renowned throughout the Midwest drawing people from as far away as California, Kansas, and Ohio.

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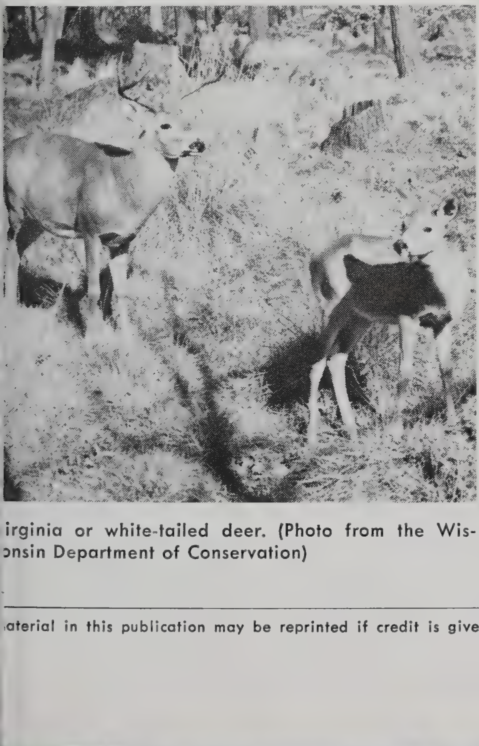
ulfur and Ecosystem Productivity

In recent years, society has been conerned with adverse effects of acid compounds of sulfur circulating in our atmophere, primarily as the result of burning ossil fuels and smelting of ores. These oncerns relate to human health, deterioraion of man-made structures, and the genral health of our ecosystems. Adverse ffects are particularly apparent where cosystems have developed on rock and eologic materials that are inherently acid r of low buffering capacity.

In an appendix in their newest book, *The iogeochemistry of Blue, Snow and Ross' eese,* Harold C. Hanson and Robert L. ones have presented examples of the association of high biomass production (particlarly animals) with high concentrations of sulfate in saline environments. For example, the western prairies are rich in sulfates of calcium, magnesium and sodium. Because rainfall doesn't exceed evapotranspiration, these nutrients are retained in the upper soil horizons rather than being leached downwards or lost to surface runoff. The capacity of the high plains to sustain huge numbers of ungulates, particularly buffalo (bison), can be related not only to protein rich grasses, but also to a luxury consumption of minerals thereby permitting bacteria and protozoa of the rumens of the animals to synthesize additional proteins and particularly to use sulfates present in the environment.



irginia or white-tailed deer. (Photo from the Wisonsin Department of Conservation)

One has only to read Audubon's journal from his travels of the upper Missouri River to appreciate the wealth of wildlife produced on the prairies. But what of the wood buffalo of the coniferous forest zone of northern Alberta? A review of the environment of these northern buffalo reveals that large portions of their range south of Great Slave Lake is underlain by gypsiferous rocks (strata of calcium sulfate). An area north of the western portion of Great Slave Lake is characterized by alkali (sulfate) encrusted botoms of dried out ponds. A desolate and seemingly unproductive appearing area, but buffalo, reintroduced to their former range, thrive there. Analogous to this mineral encrusted environment is the former range of the buffalo in a part of Wyoming where the vegetation was mineral encrusted, but the area nevertheless produced the best buffalo in respect to carcass condition, according to a frontier trapper J. Osborne Russel.

The range of the buffalo extended into the eastern and southeastern states, but early accounts indicate the relatively small scattered herds of his region were greatly dependent on mineral licks for their nutritional welfare and possibly survival. One early writer refers to "the sulphur or salt springs" at one of the famous lick sites in Kentucky. The thesis that sulfur-rich environments nutritionally benefit ruminants is also supported by a study which showed that sulfate-supplemented feeds given cattle and sheep increased the amino acids in the rumen by nine to twenty times.

Do these observed associations of wild ruminants with high-sulfur environments have any implications for the present-day livestock industry? In recent weeks, the news media have featured the experience of three Georgia farmers who obtained greatly improved growth from steers fed kiln dust produced by cement manufacturing plants. These findings have been confirmed by feeding experiments by U.S.D.A. scientists at Beltsville, Maryland. The scientists were unable to provide a rationale for the gains they found in feeding samples of the cement dust. Hanson and Jones hypothesized on the basis of their studies of sulfur in the environment that part of the gains relate directly to the sulfur content of the dust. Cement, apparently by design, contains 4-5 percent gypsum. The kiln dust fed the experimental steers contained 2.33 percent sulfur. Thus, the microflora of the rumen had an abundance of readily available sulfur for the synthesis of sulfur-containing amino acids. Proteins cannot be synthesized unless all the amino acid building blocks are simultaneously available. The microflora of the rumen synthesize the amino acids that the cow and all other mammals cannot synthesize by virtue of their physiology. The protein increment absorbed above dietary intake is obtained from the bacteria and protozoa in the rumen. This manufactured protein passes into the digestive tract for digestion and absorption.

Jones and Hanson are currently studying the composition of mineral licks of wild ungulates across the continent. Among the elements of physiological importance, sulfur and/or calcium are consistently abundant in these samples. In light of these findings and the news releases regarding the virtues of feeding cattle kiln dust produced in manufacturing cement, the following notation which accompanied a "lick" sample furnished by R. E. Keiss, a game biologist with the Colorado Division of Wildlife, is particularly meaningful: "This material is from an area where ready-mixed concrete trucks are washed. Bighorn sheep have started using this area and are specifically seeking out this material."

When wet, soils of the alkaline country of the West became anaerobic due to bacteria which reduce sulfates to sulfides. The soils then appear to be conducive to the proliferation of the bacterium *Clostridium botulinum* Type C which produces toxins deadly to waterfowl and other birds. If an association of *Clostridium* with high sulfate soils seems suspect, how do we explain the fact that the only site in Wisconsin where botulism outbreaks occur with any regularity is at the mouth of the Fox River at the south end of Green Bay? It is significant that 17 paper companies south of Green Bay have dumped sulfite liquors into the Fox River for many years and that Type E phase of the botulism organism has been found in fishes in Green Bay. Is the source of these infections — to which fish are apparently immune — also related to sulfur-rich sediments that presumably characterize the bottom of the south end of Green Bay? Can the massive die-offs of loons from botulism that have occurred in the fall on Lake Michigan have their origins in the sulfate pollution of Green Bay waters?

The hypothesis that sulfur compounds are primary constituents of both "salt licks" and wet soils associated with botulism outbreaks came full circle with the finding of a report on a lick heavily used by deer in southern Ohio. Sulfate was one of the major constituent ions found in this lick, and it had to be fenced off, for the deer using it were dying of botulism!

Nevertheless, in an aerobic situation, sulfate-rich waters of the prairie are highly productive of invertebrates which in turn form the base of the notable duck produc-

A mineral lick in Pennsylvania. Soil around rocks has been mined and eaten by deer. (Photo by J. S. Jordan, U.S. Forest Service, Warren, Pennsylvania)

tion on the pot-hole sections of the western plains. It is significant that the largest fairy shrimp known, *Branchinecta gigas,* is found in the "salt and soda sloughs" of southeastern Alberta. A recent irruption of "supershrimp" (*Axius serratus*) occurred in the Straits of Canso, Nova Scotia. Once thought to be extremely rare, these burrowing shrimp established dense populations in a highly polluted section of the straits. What were the polluting industries? A gypsum dry wall plant and a pulp and paper mill discharge wastes to these waters. Sulfates and sulfites as well as organic wastes would be major components of such waste discharges. Perhaps a capstone to the hypothesis of Hanson and Jones that an abundance of available sulfur has a profound effect on biomass production is the dramatic recent discovery of a rich oasis of invertebrate life found off the Galapagos Islands and attributed to a food chain that has hydrogen sulfide as its base (*National Geographic Magazine,* October 1977).

Numerous other examples have been located by Hanson and Jones, but in essence the investigators believe that the role of sulfur in ecological productivity is neither adequately understood nor appreciated.

Alfalfa Weevil Parasite Production

Many species of parasitic hymenoptera have been imported and released in the U.S. and Canada to help regulate populations of the alfalfa weevil, *Hypera postica* (Gyllenhal). One of the most important and successful species to be introduced is *Bathyplectes curculionis* (Thomson), an endoparasite of alfalfa weevil larvae. Through initial releases in 1911, subsequent releases, and natural dispersal, *curculionis* is now established throughout the range of its host.

Dynamic models of the alfalfa weevil's life system are being developed by Survey entomologist W. G. Ruesink for use in pest management programs. Since *curculionis* is

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such an important natural enemy, it is essential that these models include its effect on the weevil. Among the more important processes in the parasitism submodel are: 1) egg production and deposition by the parasite, and 2) distribution of those eggs among available hosts. Writing equations to describe these processes is relatively simple once the biological relations are described quantitatively. Although there is an abundance of literature pertaining to *curculionis,* only a few researchers have dealt with quantitative aspects of the host/parasite interactions, or with the effect of these interactions on the population dynamics of the alfalfa weevil.

Survey entomologists R. J. Barney and D. P. Bartell used several laboratory experiments to determine the effect of host density, temperature, and parasite age on the reproductive potential of *curculionis.* They found that nearly 100% of the host larvae were parasitized at very low host densities, while at very high host densities each parasite would attack about 30 hosts per day. In the laboratory, this parasite did not differentiate between unparasitized hosts and those already parasitized; instead it laid its eggs at random among all available hosts, even though only a single parasite can succesfully mature in one host.

Temperatures ranging from 10° to 30° did not affect the number of hosts parasitized. This means that *curculionis* can find and attack alfalfa weevil larvae successfully over the range of temperatures normally encountered in Illinois alfalfa fields.

The age of the adult parasite strongly controls its ability to parasitize hosts. During the first day of its life, each adult laid an average of 5 eggs, while on days 2, 3, and 4, averaged about 15 eggs per day. After the 4th day, very few eggs were laid, and the average age at death was 4.8 days.

Equations have been written to fit these findings, and the equations have been incorporated into the alfalfa weevil model. This is an example of the interaction between biological research and population modeling that frequently occurs: in developing a model for whatever purpose, gaps in our understanding are revealed and research must be performed to provide the needed information.

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MARCH 1978, NO. 175

Research on Urban Tree and Shrub Problems

For several years, Illinois municipalities have invested considerable sums of money for trees to replace American elms killed by Dutch elm disease. These investments have generally improved the physical environment of municipalities and have increased the aesthetic value of both private and public property. However, due to various ecological, horticultural, and pathological problems, many of the replacement trees have not survived or produced satisfactory growth. Consequently, plant pathologist Gene Himelick has initiated an extensive research effort to determine specific causes for poor survival and growth rates and to develop practical transplanting and other cultural practices that will contribute to increased plant survival and improved vigor.

The research effort will give a basis for amending and expanding the specifications for species selection, planting, and mainte-

Elms arching above an urban street. This photograph was taken in a city which has an effective Dutch elm disease control program, but in many cities the elms have died and are being replaced with other tree species. (Photo by Gene Himelick)

nance, and it will result in such tangible benefits as a shorter establishment period and fewer replacements following planting. Not only will this research offer the potential for reduced establishment and maintenance costs in the future, for both the private homeowner and the municipality, but it will also contribute substantially to the improvement of the physical-aesthetic quality of urban areas.

Several municipalities have been approached to assist in financing this research, and grant support has been received recently from four major cities.

The research is divided into three major phases. To complete each phase will require a minimum of 3 years of field work. Phase I involves the surveying of several thousands of recently transplanted trees to measure and record data on existing woody plants along municipal parkways and streets in various municipalities in Illinois. Phase II will involve identification and measurement of causes of decline in established trees in several randomly selected municipalities. In phase II the researchers will also attempt to determine which tree species, varieties, and clones do well under urban growing conditions. Tree clones showing disease and insect resistance and outstanding form and growth characteristics in the field surveys will be propagated for future evaluation and recommendation for commercial nursery production. Phase III will include intensive studies to measure the effects of various horticultural and transplanting practices as they relate to mechanical root injury, root regeneration, and diseases of tree roots which develop after transplanting.

Read Any Good Books Lately?

The library of the Illinois Natural History Survey was founded at the first meeting of the Natural History Society of Illinois in 1858 and has always had an official librarian, a professional since 1906. The original collection consisted mainly of reprints received by the members of the society and publications received through an exchange program.

In 1861 the society received its charter from the state legislature and was located at Normal. It became the Illinois State Laboratory of Natural History in 1877. It was transferred to Urbana in 1885 so that the laboratory director, Stephen A. Forbes, could also serve as professor of zoology and entomology at the Illinois Industrial University.

Dr. Forbes brought the library with him, and in 1928 it became a part of the University of Illinois Library, with the collection kept separate but made available to university students and faculty. The Natural Resources Building, which houses both the Illinois Natural History Survey and the Illinois State Geological Survey, was built in 1940. At that time the Natural History Survey Library became a full departmental library of the University of Illinois Library. An agreement was reached between T. H. Frison, Chief of the Survey, and C. M. White, Director of the University Libraries, providing that the Survey would provide the building, furniture, and staff for the library and the University Library would provide a budget for the purchase of books and serials and do the technical processing.

The library is arranged according to the Dewey Decimal System and contains about 32,000 volumes. The collection is about 80 percent serials and 20 percent monographs. A few items are on either microfilm or microfiche, and the library has a reader for each.

The exchange program, which began in the 1800's, has been maintained and expanded to the extent that about two-thirds of the library's serials come from exchange partners. The Survey sends its publications to over 550 institutions throughout the world, and in return receives their publications for the library collection.

The subjects covered in the collection reflect the research projects done by the Survey staff through the years. Entomology is the area covered most thoroughly, but there are extensive works also in botany, ichthyology, ornithology, wildlife, aquatic biology, and economic entomology.

The library is open to the public as well as University of Illinois students and faculty and Natural History Survey staff members, and the librarian is available to

llinois Natural History Survey Technical Librarian Doris Sublette reviews periodicals for articles that may ›e of interest to Survey staff members. (Photo by Survey photographer Larry Farlow)

ıelp in locating books and articles and in naking a search for literature relevant to ubjects in the area of natural history. Only nembers of the Survey staff may check naterials out of the library, but the library ıas a copying machine for the use of its ›atrons.

As a part of the University of Illinois ibrary, the Natural History Survey Li›rary participates in the extensive interibrary loan system, making its materials ıvailable to libraries worldwide. The NHS Library is an affiliate library of the incoln Trail Library System and is a nember of an informal group called PAHGEIS (Inter-Professional Ad Hoc ɜroup for Environmental Information haring).

ɫelease Cutting for Hickories

Hickory seed is a primary food of Illinois quirrels, particularly during the fall and arly winter, when both gray and fox quirrels are rapidly gaining weight and toring body fat.

Because hickories have slow growth, enerally poor form, and low market value, foresters usually have ignored them in their silvicultural studies of midwestern hardwoods. Hickories are relatively tolerant of shade and seem to increase best under light cutting, where the canopy remains intact and the faster growing trees that are intolerant of shade are unable to take over in the understory. The recent switch from selection cutting to clear-cutting threatens to reduce the amount of hickory in future stands.

Survey wildlife biologists Charles Nixon and Lonnie Hansen are investigating a number of methods for insuring that at least a few hickories reach seed bearing size in these hardwood clear-cuts.

One approach involves release cutting around selected hickory stems in 7- and 15-year-old clear-cuts, where all competing stems are removed from around a suppressed hickory. The investigators selected 24 pairs of hickory sprouts in a 7-year clear-cut and 40 pairs in a 15-year clear-cut. Stems were paired by species, total height, and stem diameter at 1 meter, and one stem of each pair, selected by coin flip, was released by cutting out all competing stems.

Three growing seasons after release,

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stems of pignut, mockernut, and shagbark hickories averaged larger stem diameters and shorter heights than the control stems. Released stems of 15-year-old mockernut hickories were significantly larger in diameter and significantly shorter in height than comparable control stems. Stem diameter and height growth of released stems did not differ significantly from their paired controls for either shagbark or pignut hickories at 7 and 15 years.

The reduction in height growth shown by released hickories is apparently a normal response to sudden release from competition. Such a response has been reported for released stems of red oak, tulip tree, black cherry, and yellow birch.

However, basing their conclusion on the results of release cutting for these species, the Survey biologists expect their released hickory stems to grow at a faster rate than the controls during the next few growing seasons. They plan to remeasure all stems after five growing seasons, at which time they hope to be able to determine if a single release cutting is a feasible means of insuring that some hickories will reach seed bearing size in clear-cuts.

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APRIL 1978, NO. 176

Vinter Feeding of Squirrels

Winter is considered a critical period 'or fox squirrels (*Sciurus niger*), and it s a breeding season for both fox and gray quirrels (*S. carolinensis*). The winter sur-'ival of potential breeding squirrels and heir reproduction depend mainly on the ize of the fall tree seed crop (mast) and n the severity of the winter. In winters f low mast and severe weather, squirrel populations may suffer.

Fox squirrels readily eat corn during the vinter months. Gray squirrels may not eat orn as readily as fox squirrels, but it may e part of their diet. Some biologists be-ieve that under certain conditions, winter eeding may be of value to squirrels. Shelled corn has been used in winter feed-ng of fox squirrels and gray squirrels, but the results of these supplemental feeding studies have been inconclusive.

Wildlife specialists Stephen P. Havera and Charles M. Nixon designed a study to determine the effects of supplemental corn supplied in winter to populations of gray and fox squirrels in mature and in pole-sized (average dbh 25.4 cm) mixed hardwood forests. Populations of fox and gray squirrels were provided with shelled corn (*Zea mays*) for three winters in a mature mixed hardwood forest and for two winters in an even-aged 40-to-50-year-old oak-hickory forest in central Illinois. Havera and Nixon found that corn provided no obvious benefits to squirrels in the mature mixed hardwood forest with respect to reproduction, population density, survival, physical parameters, or reduction in disease. In the even-aged timber, the

Fox squirrel. (Photo by former Survey photographer, W. E. Clark)

numbers and survival of squirrels were higher where corn was provided, but unauthorized squirrel hunting on one of the study areas may have influenced this result.

To evaluate the use of unharvested grain as a method of supplemental feeding for squirrels, standing corn and soybeans (*Glycine max*) were left unharvested during the fall of 1975 approximately 10 m from timber. Six rows of standing corn were left unharvested in two fields in McLean County. Four rows of soybeans were left unharvested adjacent to a mature oak-hickory stand in Shelby County. Squirrels made little use of unharvested corn and soybeans left in fields adjacent to woodlands, but use of corn increased somewhat in March.

Havera and Nixon concluded that corn apparently is not a nutritionally adequate supplemental food for squirrels. They also do not believe that winter feeding with corn or soybeans is justified during most winters in the Midwest. The natural composition and diversity of the hardwood forests in the Midwest insures, except in extreme mast failures, that squirrels will find adequate nutrition. Havera and Nixon found that fox squirrels collected throughout Illinois in early spring were in just as good physical condition as those collected in the fall, and that fall-to-spring survival of squirrels on their study areas was higher than spring-to-fall survival. Perhaps winter is not as critical a period for squirrels as it is often considered to be.

Lake Shelbyville Mercury

In 1974, wildlife specialist William L. Anderson and analytical chemist Kenneth E. Smith found that muscle tissues of largemouth bass in Lake Shelbyville contained concentrations of mercury which exceeded the 0.5-part-per-million (ppm) limit set by the U.S. Food and Drug Administration. Subsequent collections and comparative analysis by several laboratories confirmed these levels in both largemouth bass and walleyes. These fishes are near the top of the aquatic food chain, and the appearances of high mercury concentrations in their tissues is indicative of mercury contamination at lower trophic levels and quite probably in the lake itself. Because Lake Shelbyville and its watershed are in a prime agricultural setting with little industrialization, these excessive mercury concentrations are particularly distressing.

Attempts to support further research met with success in October 1977, when the Illinois Institute for Environmental Quality and the Illinois Natural History Survey funded the current project to investigate the occurrence, distribution, and accumulation of mercury in Lake Shelbyville and its biota. Planned as a 2-year study under Smith's direction, this study will sample the water, soil, sediment, aquatic and terrestrial plants, benthic organisms, plankton, and fishes of the lake for mercury analysis. Results of these analyses will hopefully answer the question of the origin of the mercury in the lake, its overall distribution, and how completely it has infiltrated the food web of the lake. It is also hoped that the results may allow the avoidance of similar problems in other lakes in mid-America.

To date, samples of lake sediment and monthly water samples from Lake Shelbyville have been analyzed for mercury by cold-vapor atomic absorption spectrophotometry. Of the water samples, only the October samples showed values above 0.1-part-per-billion (ppb), the detection limit of the procedure, and ranged from 0.1 to 9.4 ppb. The samples collected during November and December were uniformly at 0.1 ppb detection limit. It's possible that the November samples were abnormally high, or that water from the lake contains much lower mercury concentrations than do autumn waters. Spring and summer samples should resolve this question during the coming year.

The analysis of the sediment samples gave wide ranging values from <1 to 230 ppb without any apparent pattern among the samples. Interpretation is complicated by the varying particle sizes in the sediment samples. Experiments are in progress to relate the particle size to the amount of mercury that can be absorbed by the sediments. These data should allow for better

'herormone trap for black cutworm baited with virgin female. (Photo by entomologist Brian Melin)

nterpretation of the mercury in sediment lata from Lake Shelbyville.

3lack Cutworm Trapping

The life history of the black cutworm, *4grotis ipsilon,* is not fully known for the ıorth-central United States where the lestructive larval stage attacks seedling :orn during May and early June. The ›rigin of these larvae has been the subject ›f debate. Did they overwinter as larvae, ›r did they arise from eggs laid early in he spring?

A study by entomologists Lynn Pautler, Villiam G. Ruesink, Hans Hummel and Villiam H. Luckmann was undertaken to levelop and test a method for early season letection of adults in Champaign County, llinois. A sticky trap baited with virgin emale black cutworm moths reared in the aboratory along with a blacklight trap vas evaluated to determine which method vas the better indicator of adult black :utworm presence and density. The virgin emale black cutworm produces a pheror-none which attracts male moths and the blacklight trap attracts both sexes of moths. The traps were all located in an abandoned orchard converted into a tree nursery in Urbana, Illinois.

The earliest black cutworm moths trapped were two males, one taken on March 14 and the other on March 15, 1977, in the sticky trap baited with virgin female moths. Additional male moths were caught in the sticky traps on March 27 (two) and on March 28 (14). During this period (March 15 through March 31) the blacklight traps caught three males and one female moth.

Seedling corn damaged by third and fourth instar black cutworm larvae was found in a field near the study area on May 11, 1977. The centigrade-degree-day accumulation from April 1 to May 11 was 210, an amount sufficient for development from oviposition to third and fourth instar larvae. It seems likely, then, that the larvae damaging corn in Champaign County in May developed from eggs laid by moths flying in early spring, rather than having overwintered as early instar larvae.

For the entire season 2.6 times more males were captured by the traps baited

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with virgin female moths than by the blacklight traps. More importantly, the baited traps attracted 6 times more males during March through May than did the blacklight traps, and the blacklight traps failed to detect the early moths (mid-March) caught in the baited traps.

More Flies – the Genus Dialysis

As part of an ongoing systematic study of lower brachycerous flies, Survey entomologist Donald Webb has recently revised the genus *Dialysis*. This study involved borrowing specimens from some fifty museums and universities, in addition to private collections. Over 1,000 specimens were examined, involving nine species.

The genus *Dialysis* is widely distributed in the United States, occurring from California to the Canadian border east to southern New Brunswick and northern Georgia. Three of the nine species occur in Illinois. Adults can be collected on herbaceous vegetation in wooded lowlands from April to August. The immature stages of this genus are unknown in North America, and little of their adult biology has been determined.

The study has involved descriptions of two new species and the synonymy of two species names with previously known species. Descriptions, keys, illustrations of morphological characters, and the distribution of each species were presented. This study is another segment of an overall study to examine the phylogenetic relationships of several genera of lower brachycerous flies and is preliminary to a faunal study of the flies of Illinois.

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NATURAL HISTORY
SURVEY REPORTS

MAY 1978, NO. 177

;reen Slime and the Gizzard Shad

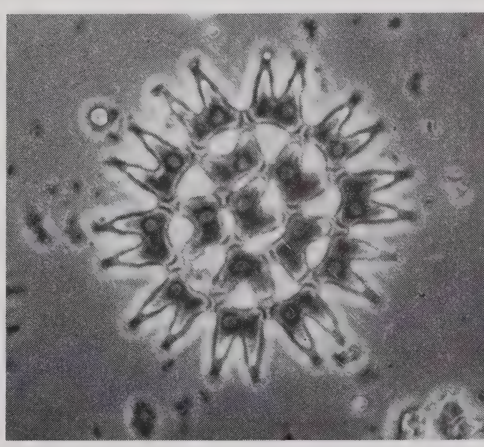
Several unflattering names, such as pond cum, green slime, and even frog spittle, ave been used for plants properly known s algae. Most people are aware of algae s the green scum that floats on ponds and akes in mid to late summer, but few realze that certain kinds of algae are also susended in the water column and are atached to the sediments under the water nd along the shore. Examples of phytolankton (algae suspended in the water) nd periphyton (algae attached to the lake ottom or to objects in the water) illusrating their beauty and uniqueness of hape are *Pediastrum duplex* var. *reticulaum* and *Gomphonema acuminatum* also nown appropriately as the "naked lady."

Algae constitute a major part of the oranisms that convert sunlight into organic natter in most waters, and algae are reponsible for the production of a large perentage of the atmospheric oxygen. These lants also provide food for zooplankton weakly swimming microscopic animals), vhich in turn are consumed by certain ishes. Some fish are even directly depenlent on algae for food; one of these is the izzard shad.

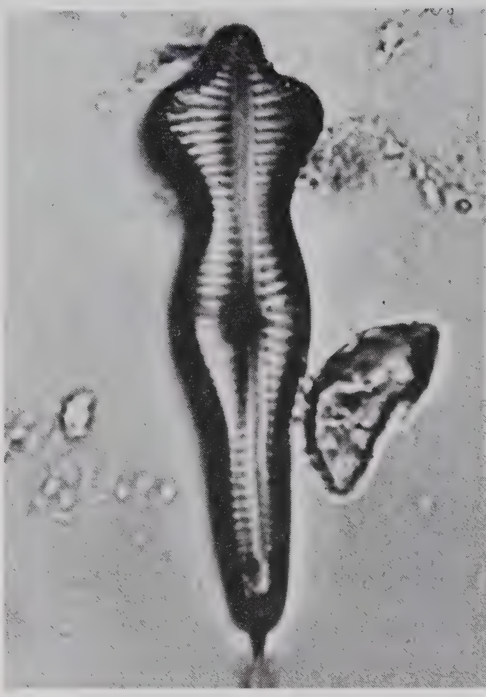
Although the gizzard shad is not a fish ought by fishermen, it is probably the most mportant forage fish found in midwestern akes and reservoirs. The gizzard shad is herefore a direct link between algae and he game fishes. The successful spawning nd growth of the gizzard shad are imporant for the success of many game fish, specially the largemouth bass, which is strongly dependent on the shad for food. It is therefore important to understand the reproduction, growth, and feeding habits of the gizzard shad. Understanding the importance of periphyton and phytoplankton abundance to the success of the gizzard shad could lead to better fish management in the future.

In relation to gizzard shad feeding habits, phycologist Larry Coutant has studied the dependency of gizzard shad on algae for food in two Illinois lakes during 1975 and 1976. The two lakes studied were Lake Sangchris, a power plant cooling lake, and Lake Shelbyville, a river reservoir. Analyses were carried out in part to determine gizzard shad food sources and possible power plant influences on shad diet and feeding behavior.

Gizzard contents of shad from 40 to 340 mm in length from different areas of the



Pediastrum duplex var. *reticulatum*, an alga common in phytoplankton.



Gomphonema acuminatum, the "naked lady," an alga common in periphyton.

two lakes contained primarily algae, particularly pennate diatoms, a special group of algae common to most waters. Blue-green algae, pigmented protozoans, and zooplankton were also present in gizzard contents but were less common than diatoms.

Certain groups of algae are found primarily in the phytoplankton, and other groups of algae (including certain pennate diatoms) are found primarily in the periphyton. Therefore, it is possible to determine from the algae found in their gizzards where gizzard shad of different lengths were feeding.

Smaller gizzard shad ate more phytoplankton than did the larger gizzard shad, which apparently ingested more periphyton. This trend was less apparent in shad from Lake Sangchris, but some evidence of this relationship was found there as well as in Lake Shelbyville.

Another interesting result was that the highest concentrations of organisms were found in shad taken from the power plant intake arm of Lake Sangchris, while the lowest organism concentrations were found in shad from the discharge arm of Lake Sangchris. Shad from two locations in Lake Shelbyville produced results intermediate between the values obtained from Lake Sangchris. These results may be due to the availability of algae in the locations where shad were feeding. Certain minimum algal populations may even prove to be of major importance for adequate maintenance of gizzard shad populations.

Studies of gizzard shad feeding habits have greatly increased our understanding of the importance of fish-food organisms in fisheries. The monitoring of many fish-food organisms, including periphyton and phytoplankton, may prove to be more and more valuable to the proper management of bass and other game fish in the future.

Computer Storage of Soybean-Pest Literature

Since 1969 the Illinois Natural History Survey and the University of Illinois have been studying arthropods associated with soybeans. Because of the economic importance of this crop, this program has created two service-oriented units that support its research projects.

One of these units is the Soybean Insect Research Information Center (SIRIC), which operates a computerized information storage and retrieval system on the literature of insects and mites associated with soybeans.

Initially, Jenny Kogan and her associates at SIRIC used a manual system, but with the rapid increase, beginning in the late 1960's, in the number of papers published on soybean pests, a computerized system was required.

The objectives of SIRIC are:

1. To compile literature on soybean-related insects and mites and to establish a data bank for this literature
2. To organize a collection of relevant documents (journal articles, book chapters, reports, etc.), using code word descriptors for input and computerized retrieval
3. To compile and publish bibliographies of key soybean pests
4. To help soybean researchers, extension workers, and others with their information needs

The SIRIC literature collection now approaches 17,000 documents with about 16,500 documents fully processed and stored on magnetic tapes. Copies of the documents are filed by accession number. Bibliographic references to these documents are stored in a computerized file for retrieval on the Cyber 175 computer of the University of Illinois.

To select items to be included in the data base, SIRIC researchers check standard abstracting and indexing journals or their computerized data bases. They carefully check all documents that are added to the system for additional references. In addition, they correspond with researchers in the USA and abroad to obtain relevant documents. These articles are often published in foreign journals not easily located in U.S. libraries, making SIRIC a valuable depository of foreign soybean entomology literature.

The criteria adopted for selection of relevant documents are: (a) papers that deal with soybeans and with soybean-associated insects or mites, including their natural enemies; and (b) papers that deal with a list of selected soybean pests and their important natural enemies. The literature of these species is surveyed independently of their plant associations. For this reason SIRIC contains many documents on crops other than soybeans, such as corn, cotton, and alfalfa.

Requests for service are received from researchers, extension workers, students, and other interested persons working with soybean insects here and abroad. Computer searches reflect the information needs of users and the subject contents of documents in the data base. A key component of the system is its controlled vocabulary. A Hierarchical Code Descriptors (HCD) thesaurus, specially compiled for SIRIC, is used in input and output operations.

Bibliographies compiled and published within the framework of SIRIC have been widely distributed to interested researchers. Four bibliographies have been published in the series on the literature of arthropods associated with soybeans, and a fifth bibliography is in its final stages of preparation. It is a compilation of the literature of two species, *Heliothis zea* and *H. virescens*, considered the number-one agricultural pest complex in the USA. This bibliography will contain about 5,800 references and a complete subject index as a preliminary key to this huge literature.

SIRIC is housed in the Illinois Natural History Survey and is sponsored in part by INTSOY, the University of Illinois International Soybean Program; the Office of International Agriculture of the University of Illinois; and the Illinois Agricultural Experiment Station.

New Method of Estimating Wildlife Abundance from Livetrapping Data

Viable population estimates or indices of abundance are essential to many ecological investigations. Most wildlife species can not be counted directly because of their secretive behavior. Capture-recapture methods have long been used to estimate the abundance of such species as cottontails, squirrels, and other small mammals. Numerous estimators have been proposed for use with livetrapping data, most of which assume some combination of random, uniform, or constant probability of capture. Wildlife specialist William R. Edwards has used 22 years of data from cottontails livetrapped at Allerton Park to evaluate methods of estimating abundance from capture-recapture data. He rejected the usual methods of population estimation because probability of capture is not random, uniform, or constant.

Frequency of capture typically follows the geometric, and frequently the negative, binomial distributions. Edwards' current study demonstrates that past difficulties with the geometric and negative binomial estimators have been caused by sampling intensity bias. Higher rates of capture than are typically obtained are needed to minimize that bias.

Edwards found that two of the geometric estimators had biases that tend to offset each other when the estimators are combined. He has proposed a combined estimator as the "best" one for use with livetrapping data, provided the data approximate the geometric distribution. Be-

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cause livetrapping data usually do approximate that distribution, the combined estimator should be very useful in population studies of rabbits and other small mammals.

Edwards cautions that in any livetrapping study what is being estimated is the number of animals that have had a positive probability of capture at some time during the trapping period. This estimate is not necessarily an estimate of the number of individuals on the area at any given time or even of the number whose centers of activity fall within the study area. It is not legitimate to relate population estimates to the area trapped in order to estimate the population density of animals on the area trapped. Livetrapping can only estimate the individuals that used the area during trapping. The reasons for rejecting estimators often used in wildlife population studies also hold for estimates based on visual observations of color-marked or tagged animals, because those animals do not have the required random, uniform, or constant probabilities of observation.

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NATURAL HISTORY SURVEY REPORTS

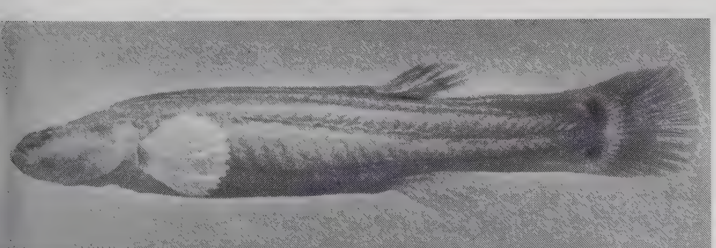
JUNE 1978, NO. 178

The Spring Cavefish

The cavefishes make up a family of only six known species, all occurring in the eastern half of the United States. All but two of them are eyeless, unpigmented, small fishes confined to streams in the deep recesses of caves and known to visitors of commercialized caves. The exceptions are two species in the genus *Chologaster* (meaning mutilated belly in reference to the absence of pelvic fins). One of them is pigmented, eyed, and lives in surface waters on the Costal Plain of the Southeast. The other is intermediate in almost every way between surface-dwelling fishes and the true cavefishes. It is known from a few springs and caves in Tennessee, Kentucky, southern Illinois, and extreme southwestern Missouri. It is the subject of a new Survey publication entitled "A summary of the life history and distribution of the spring cavefish, *Chologaster agassizi* Putnam, with population estimates for the species in southern Illinois." The paper was written by Survey ichthyologist P. W. Smith and N. M. Welch, a physician on the staff of a Dallas, Texas, hospital. Copies are available upon request to this agency.

Since this three-inch, semi-translucent fish bridges the gap between an existence above ground and in subterranean waters, it is a curiosity often sought by collectors. Several state conservation departments and the U. S. Department of Agriculture Forest Service became concerned that its numbers might be seriously depleted from over collecting. The Forest Service in 1973 employed Dr. Welch to census the numbers of this fish in several springs in the LaRue-Pine Hills Ecological Area of Union Co., Illinois. This he did by dipnetting specimens at night in springs and marking them with an injection of tattooing ink. Then by using a mathematical formula called the Petersen Index, he could calculate the probable number of individuals present based on the proportion of marked to unmarked fish taken on each visit. He found that in eight springs studied the number of fish ranged from one to 302 individuals for a probable overall total of 785 ± 314 fish — thus fewer than 1,000 individuals in the gene pool.

All known aspects of the life history of the species were summarized in the report. It was found that breeding occurs underground in winter, that the 80 to 285 eggs



An adult spring cavefish from a spring along Big Creek, Hardin Co., Illinois. (Photo by L. M. Page)

produced by one female are almost two mm in diameter, that the fish grows on an average of 10 to 20 mm per year, that it rarely attains an age of three years, and that in springs it feeds primarily on one kind of amphipod but in caves is strongly cannibalistic (caves have a very limited food supply). Many facets of its reproductive cycle are still unknown. It emerges into springs at dusk but usually retreats underground just before daylight. It is most often found when springs have heavy outputs such as after rains. Its eyes are so poorly developed that it relies on smell and touch to discern its food. It has evolved an ability to withstand without acclimation higher water temperatures, which offers some protection to a little fish sometimes swept into warm surface water by copious spring flow. The spring cavefish is superbly well adapted to a very difficult way of life.

Turfgrass Insect Problems

Insects infesting home lawns have usually been either the sod webworm, *Crambus trisectus* or the annual white grub, *Cyclocephla immaculata.* The sod webworm occasionally is a serious problem in late July and August especially in the central and northern areas of the state. The buff-colored moths lay eggs while in flight on the best fertilized and watered lawns in an area. The first generation appears in June and there is never enough of a population to cause damage. The second generation in late summer can be damaging. The larvae damage the grass by cutting shoots off about ⅛ inch above the crown rather than 1½ to 2 inches as recommended for proper mowing of a lawn.

Annual white grubs are increasing in both numbers of lawns infested and the area of Illinois in which it is being commonly found. The grubs are white with brown heads and C-shaped, and feed on the roots of bluegrass causing the sod to be severed from the soil surface. Counts of 12 to 50 grubs per square foot can be found in most lawn areas from about Interstate 70 on the south to Interstate 80 on the north across the state from east to west. Tan, half-inch long, adult beetles emerge in June from the sod and soon lay eggs. The eggs hatch in July and damage can be observed, if grubs are present, after mid-August until early November. The grubs overwinter below the frost-line deep in the soil.

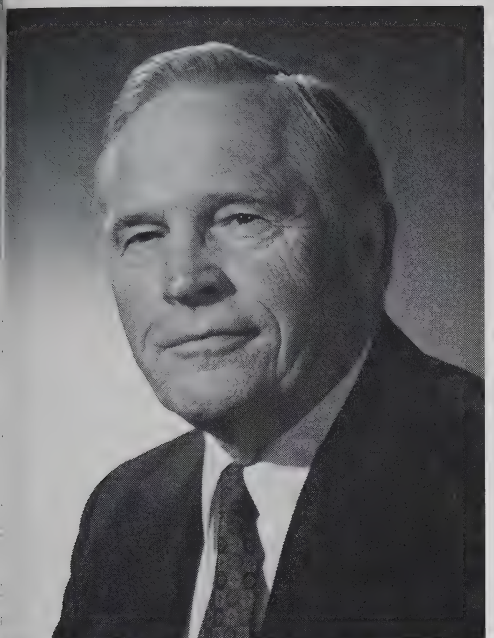
Two insects which were found in damaging numbers in golf course turfgrass during 1977 included a sod webworm, *Crambus teterrellus* commonly called bluegrass webworm and a small grub, *Ataenius spretulus.* The bluegrass webworm was severely damaging the bentgrass golf greens by feeding on the roots as a soil insect. The *A. spretulus* has been observed during the past four years feeding on the roots of bentgrass and annual bluegrass commonly found in the fairways. Numbers of both bluegrass webworm and *A. spretulus* were very high on some golf courses. As many as 200 or more webworms per square foot were found under bentgrass sod in western Illinois. *Ataenius* grubs numbering over 300 per square foot were found in the Chicago area.

Chemical control evaluations continue to be done for control of grubs and webworms. There are many labeled and effective sod webworm control insecticides for use by the home lawn owner and managers of other turfgrass areas. Many insecticides are very effective for grub control if applied in late summer or fall. But only two are labeled at the present time with one, diazinon, being the only one available in garden centers and other stores selling pesticides to homeowners.

Illinois Mollusks

In May Professor Emeritus Max R. Matteson of the University of Illinois deposited his personal collection of naiad mollusk shells in the permanent research collections of the Illinois Natural History Survey. His specimens, described by several biologists as the finest state collection of mussels in existence, is being put in order by one of his former students, Mrs. Liane Suloway. His material will be referred to as "The Max R. Matteson Mollusk Collection."

Dr. Matteson joined the Zoology faculty in 1947 and soon thereafter embarked on a quantitative survey of the mussel fauna



Dr. Max R. Matteson. (Photo by Gliessman Studios, Champaign)

of the inland rivers of Illinois. Throughout the 1950's and well into the 1960's, he and a research assistant conducted transects of streams at three, seven, and 15-mile intervals on 22 different streams in the state. The collecting sites were randomly selected on quadrangle maps the night before each visit, but the precise transect made at places judged typical for the stream with access and a riffle or raceway shallow enough to be worked from one bank to the other. Sight from above the water, snorkeling, and groping were employed, depending on which method was appropriate. Dr. Matteson and assistant worked steadily at each site for three hours before moving to another so that the number of each clam species could be expressed in man-hours of effort.

Since dead shells could be transported downstream by cakes of floating ice, only living animals were taken. Each had to be boiled, fleshed, and thoroughly scrubbed. The dried shells were subsequently sorted and identified. Meticulous field notes were recorded, and a sketch of each site drawn. If no shells were found after three hours, the station was still recorded, and the reasons for the absence of mollusks noted. The field notes list numbers of each species found at every station.

The stream collections represent 225 sites. The Illinois River was, of course, too deep to be worked from one bank to the other, and another river in southwestern Illinois was avoided because Dr. Matteson didn't like snakes! Collections are available from several stations now inundated by large reservoirs such as Shelbyville and Carlyle, and all of them were made before the peak of the present environmental crisis. Environmental degradation was relatively minor in many parts of the state in the 1950's. Other samples are present from ponds in Illinois and streams in Indiana and Michigan. The collection is of enormous value in providing quantitative baseline data that enable reconstruction of native habitats and their degree of deterioration at that time. It will provide priceless information for environmental impact statements and will be an important resource for future ecological studies of our aquatic environments.

Wandering Weevils

The detection in Illinois in May 1977, of the imported crucifer weevil, *Baris lepidii,* was unusual in the sense that the insect was first found established in the Western Hemisphere in Illinois. It was not the first time that an immigrant species of weevil has found its way to the state. Since the period of the Civil War, at least one species per decade on the average, of these wandering weevils has become established in Illinois and many are of concern to agriculturalists of the state.

The cabbage curculio, *Ceutorhynchus rapae,* another European pest of cruciferous crops, including cabbage and horseradish, was first detected in the United States in New England in 1855. A specimen in the Illinois Natural History Survey was collected in the central Illinois city of Bloomington on May 15, 1882. Also from Europe are three species of *Otiorhynchus, O. ovatus,* the strawberry root weevil, *O. sulcatus,* the black vine weevil, and *O. rugosostriatus,* the rough strawberry root weevil. These damaging weevils feed as

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larvae on the roots of a variety of cultivated plants and they are frequently received at the Illinois Natural History Survey for identification and for recommendation for control measures. Several of the *Otiorhynchus* species were detected along the eastern shore of the United States from 1835 to 1876, and one of them, the strawberry root weevil, was taken at Urbana as early as 1891.

Perhaps the most damaging European import has been the alfalfa weevil, *Hypera postica*. The eastern strain of the alfalfa weevil was detected in Maryland in 1952. By 1964 it had entered Illinois, and it is now well established throughout the state. Pest management of the alfalfa weevil is a matter of serious concern to growers of alfalfa in Illinois.

Japan has also been a source of pest species. Since 1940, three such Oriental weevils, *Calomycterus setarius*, the imported longhorned weevil, *Cyrtepistomus castaneus*, the Asiatic oak weevil, and *Pseudocneorhinus bifasciatus*, the Japanese weevil have become established in Illinois. The most recent of these to arrive in the state, the Japanese weevil, was identified by Survey entomologist, John K. Bouseman, upon its detection at Murphysboro in the southern part of the state in 1976. In addition to feeding as adults on the foliage of a wide variety of cultivated plants, the imported longhorned weevil and the Asiatic oak weevil frequently enter households in large numbers, thus giving them status as a general nuisance, and are very frequently received at the Illinois Natural History Survey for identification.

With the advent of rapid air transportation, we may expect to see more of these unbidden guests arrive in the state. Formerly such tramp species had to undergo the quarantine of a long voyage. Now they can travel long distances in a few hours. The presence of a large reference collection at the Illinois Natural History Survey helps to insure that any such future immigrant will be quickly identified after its detection in Illinois.

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NATURAL HISTORY SURVEY REPORTS

SEPTEMBER, 1978, NO. 179

Cooling Lake Study

The Illinois Natural History Survey has signed a research contract with Central Illinois Public Service Company (CIPS) to investigate the environmental effects of the CIPS Coffeen Power Station on Coffeen Lake, located 8 miles southeast of Hillsboro. The 3-year study will include coordinated investigations of the physical, chemical, and biological aspects of this power plant cooling lake. Individual research projects included within this study will be investigations of water quality, aquatic macrophytes, phytoplankton, zooplankton, benthos, fish, and trace metals in the biota.

Drs. John Tranquilli and R. Weldon Larimore, principal investigators of the study, said that the investigation is designed to determine whether Coffeen Lake and Shoal Creek, its receiving stream, are environmentally acceptable in terms of supporting shellfish, fish and wildlife, and recreational uses consistent with good

Central Illinois Public Service Company power plant on Coffeen Lake. This cooling lake is to be the subject of a 3-year study.

management practices. Jim Buckler will be the project leader and will be stationed at the field laboratory, located in Taylor Springs, Illinois.

It is hoped that, at the end of this 3-year study, recreational facilities may be developed through the cooperation of CIPS and the Illinois Department of Conservation.

Effects of Drought on Plant Membranes

The membrane is an essential part of all living cells, and the plant cell is no exception. The membrane (plasmalemma) forms the major barrier between the interior of the cell (protoplasm) and the external environment. The biological membrane is semipermeable (it permits the passage of some molecules but not others), allowing water to enter the cell at a faster rate than most solutes can enter. In the root system, the membranes control the uptake of water and nutrients, and only through the action of a semipermeable membrane can the proper water status be maintained. Within the plant, membranes also control the movement of solutes and water, and without this control mechanism the plant could not survive.

A plant is composed of 80-90 percent water. The movement of water from the roots to the leaves is extremely important, because the nutrients for proper plant growth are carried along in the water. Most of the water that is taken up by the plant is lost through the leaves by transpiration. The water status of the plant is a function of water uptake and water loss, and certain environmental factors influence this ratio by changing the behavior of membranes.

Claus Grunwald, plant physiologist at the Survey, is studying the effects of water stress (drought) on plant membranes, especially as the stress factor might change the chemical makeup of membranes. Biological membranes are composed of proteins and lipids at about a 1:1 ratio. A number of environmental factors produce small changes in the lipid component of membranes, and it is believed that these slight changes have a significant influence on the behavior of membranes.

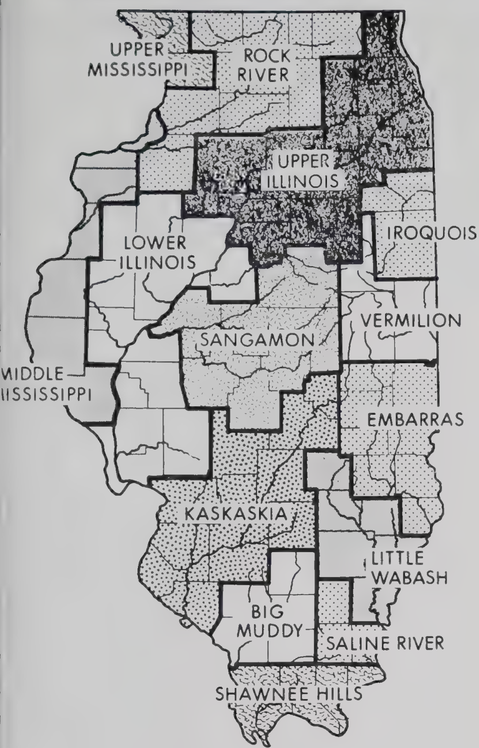
For example, low temperatures reduce the uptake of water, and this reduction is due to a decrease in membrane permeability. It is thought that a change in sterol composition and fatty acid saturation occurs as the growing temperature is changed. Whether similar changes occur under drought conditions is presently not known, but many cellular activities are very similar under water and temperature stresses. An understanding of any changes in plant membrane behavior or chemical composition resulting from drought could help us in minimizing the effects of drought on field crops and other plants.

The Gray Squirrel in Illinois

The flora and fauna present in Illinois when the first white settlers moved north and westward across the Ohio River have undergone drastic changes during the past 175 years. This change is particularly true for the gray squirrel, a species adapted to large expanses of old-growth hardwood forests. Extensive clearing of the virgin forests following white settlement led to the virtual disappearance of gray squirrels in many of the central and northern counties early in this century.

Survey wildlife biologists C. M. Nixon, S. P. Havera, and R. E. Greenberg have documented these changes in gray squirrel abundance in a new publication, "Distribution and Relative Abundance of the Gray Squirrel in Illinois," published by the Survey as Biological Notes No. 105. Copies of this publication may be obtained free by writing to the Chief, Illinois Natural History Survey.

To determine the present status of the gray squirrel, Nixon and his co-workers divided Illinois into 14 watersheds (see map) and in each watershed contacted cooperators thought to have knowledge of gray squirrel abundance. Cooperators were requested to indicate the townships presently "occupied" by gray squirrels and to indicate their relative abundance as: *Common* — frequently shot or seen, *Scarce* — shot or seen every year but only in low numbers, *Rare* — shot or seen infrequently (every 2 or 3 years), or *Absent*. Supervisors of urban parks were also contacted in all the major cities of Illinois to de-



he major watersheds of Illinois, used to delineate ie present distribution and relative abundance of ie gray squirrel.

ermine the urban distribution of gray quirrels.

Gray squirrels were found to be gen-rally distributed throughout the Shawnee Iills, Saline River, and Big Muddy water-heds, and to be common in the southern ortions of the Kaskaskia, Little Wabash, nd Embarras basins. In the remaining vatersheds, however, gray squirrels were ound to be widely scattered, with large reas of unoccupied range in each water-hed.

Why has the gray squirrel fared so oorly in this century while the fox squirrel as increased in abundance during the ame period? The answer lies in the differ-ng habitat requirements of each species. Gray squirrels favor extensive forests of nature hardwoods, while fox squirrels are dapted to woodlots, hedgerows, and rela-ively young and open forests. Thus, the ransformation of Illinois from a wilder-ess to a modern technological society has avored the fox squirrel, because much of he forest cover present in Illinois in 1800 has been destroyed (declining from 15.25 million acres to the present 3.7 million acres or less). There is a significant relationship between the percentages of gray squirrels killed in each county and the percentage of each county that is forested.

What does the future hold for the gray squirrel in Illinois? The human population of the state is predicted to increase from the present 11 million to nearly 14.5 million by 1990. This increase in human population will place even more pressure on the already distressed forest ecosystems. Gray squirrels are expected to continue to decline in numbers in the Upper Mississippi, Rock River, Upper Illinois, Sangamon, Vermilion, and Iroquois drainage basins. They are also expected to experience further declines in the upper reaches of the Kaskaskia, Little Wabash, and Embarras basins if stream channelization and conversion of forests to tillable land continue at the present rates. Gray squirrels should be relatively secure in the lower portions of these basins as well as in the Big Muddy basin, the Shawnee Hills, and portions of the Saline River basin. However, as new water impoundments are created, more acres are strip mined for coal, and towns and cities expand, gray squirrels will become locally scarce or absent even in these extensively forested basins.

Progress Report on Introduced Lady Beetles

A large population of the seven-spotted lady beetle, not native to North America but found throughout much of Europe, Asia, and India, was located in New Jersey in 1974. In 1975 Survey entomologist Clarence White began receiving shipments of these ladybugs from the U.S. Department of Agriculture, and he traveled to New Jersey to collect beetles. Like most species of lady beetles, these feed on other insects and their eggs and help to control insects that are harmful to agricultural crops and ornamental plants. These beetles, however, are about twice the size of the native ladybugs, and they feed heavily on aphids.

White has released thousands of these lady beetles at several locations in Cham-

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paign County in 1975, 1976, and 1977. Last November, 13,000 adult beetles were placed in overwintering cages in the forestry plantation south of Urbana. The cages have openings which allow the insects to disperse naturally in the spring.

Searches of the 1975 and 1976 release sites have not revealed any evidence that the beetles are reproducing and establishing a permanent population here. However, White did find evidence of reproduction in 1977 near a release site in the Salt Fork River Forest Preserve near Homer and at another site near Mayview. The fact that larvae were observed in the summer and adults in the fall is encouraging, but is not proof that they have established a population here.

By conducting a selective-breeding program in the laboratory, White has obtained, in nine generations of beetles, a strain that produces not one but several generations each year. This lady beetle breeding and release program is only one of many on-going attempts by Survey researchers to find natural, in addition to chemical, means of controlling harmful insects.

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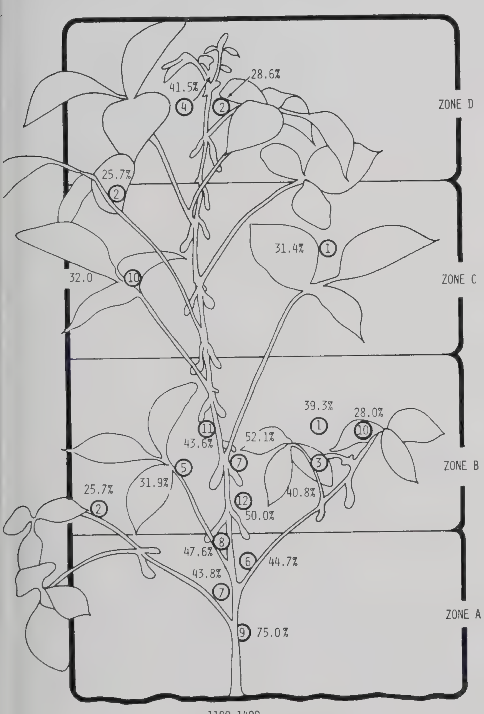
NATURAL HISTORY SURVEY REPORTS

OCTOBER 1978, NO. 180

oybean Spiders

Spiders are receiving considerable atten-:on as potentially important predators of rthropod pests of agricultural crops be-ause of increased interest in the develop-nent and use of integrated pest-manage-nent systems. However, reports quantifying pider populations, showing colonization ates, and listing prey preferences of the ominant spider species in row crops are acking. Entomologists C. D. LeSar and J. D. Unzicker, with support from the Section of Economic Entomology and the Illinois Agricultural Experiment Station, undertook a study of spider species composition, population densities, and vertical distribution in soybeans in order to provide information on these predators in soybean fields.



Locations of the 12 most abundant spider species on soybeans during the 1100-1400 time period with percentages of each species present. (Diagram by Lloyd LeMere, Survey artist)

Over 4,100 spiders, representing 77 species, were collected in five fields during two seasons. Colonization of the fields began in mid-June, after insect colonization had begun, and continued until mid-August. Early colonizing spiders during 1975 suffered high mortality rates because the small soybean plants offered little protection from heavy rains. Only 13 of the 77 species collected during the 1975-76 growing seasons became firmly established on the soybean plants.

The data from three combinations of fields and/or years were analyzed and compared for species diversity. Diversity was higher in 1975, when a very wet growing season suppressed the dominant species, *Tetragnatha laboriosa,* causing a greater evenness of distribution among the remaining species in the population. In 1976, when a relatively dry summer allowed the build-up of the dominant spider, the spider species in the total sample became uneven in their abundance, causing the diversity to decline. Spider diversity was high when adjacent fields sampled in different years were compared, while widely separated fields sampled the same year had similar values. This suggests that differences in habitats adjacent to the soybean fields (e.g., woodland versus native grasses) played a major role in species composition.

Species diversity was greatest after the soybean plants matured and the foliage provided the greatest number of niches for the spiders and prey. Population densities peaked during early September and then fell rapidly as the soybean plants reached senescence.

The soybean plant was divided into four vertical zones of about 250 mm each for stratified sampling. Sampling showed that two-thirds of the entire spider population was located on the lower one-half (Zones A and B) of the plant during any time period of the day. There was a great deal of species shifting which is likely determined by heat and humidity stress, as well as availability of prey. A two-way analysis of variance indicated that the six most common species had significant differences in location of the population between zones and/or the different time periods of the day. The locations of the 12 most abundant spider species on soybean plants between the hours of 11:00 a.m. and 2:00 p.m. is shown in figure.

Spiders are indiscriminate predators which feed on beneficial as well as insect pest species and, with the exception of *T. laboriosa*, do not reproduce in soybean fields. Thus the spider population in a given field cannot respond numerically to increases in prey densities. However, there may be a functional response to changes in prey densities in which additional spiders are recruited from areas adjacent to the fields. The authors recommend additional research to explore the role of these predators in agrosystems including: (1) determination of spider species commonly found in major agricultural crops, (2) studies on the migration and dispersal patterns of the major spider species, and (3) laboratory feeding studies to determine the potential impact on insect pest species.

Lake Michigan Diversion

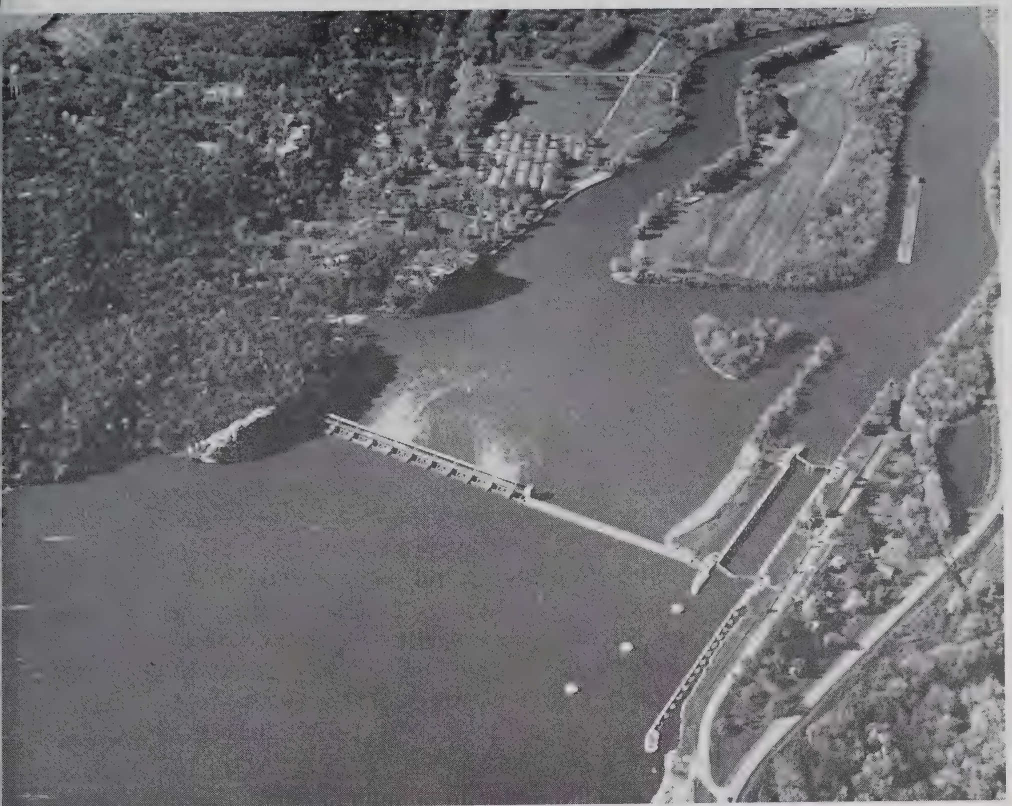
Ever since the turn of the century, a major part of the water in the Illinois River has come from Lake Michigan. Currently, lake water is diverted into the Illinois Waterway at Chicago at an average rate of 3,200 cubic feet per second (cfs). By comparison, the average flow of the Illinois River at Kingston Mines (182 miles downstream) is 9,000 cfs or less during half the year.

Now much more water may be on the way and the Natural History Survey will help evaluate the effects. Congress has authorized a temporary one-year tripling of the Lake Michigan diversion rate to 10,000 cfs, in order to determine how increased diversion would affect the levels of the Great Lakes and water quality and flooding in the Illinois Waterway.

The Chicago District of the U.S. Army Corps of Engineers has asked the Aquatic Biology and Wildlife Research Sections of the Natural History Survey: (1) to provide a preliminary assessment by December, 1978, of the expected effects of increased diversion on fish, wildlife, and vegetation in and along the Illinois River; (2) to conduct a baseline survey of existing biological conditions in and along the Illinois River; and (3) to monitor the biological effects of the temporarily increased diversion, which is scheduled to begin in the fall of 1979. Aquatic biology staff, under the supervision of Richard E. Sparks and Kenneth S. Lubinski, are reviewing available literature and are also computerizing and analyzing previously unpublished data for the preliminary assessment.

Between 1931 and 1972 D. H. Thompson and W. C. Starrett conducted fish population surveys in the Illinois River and its bottomland lakes. Their surveys spanned a period in which Lake Michigan diversion varied and in which there were several floods and droughts in the river basin. Present survey staff are continuing and replicating these studies. Information about relationships between fish populations, water levels, and river flow should make it possible to predict some of the effects of increased diversion on fish.

Wildlife biologists Frank Bellrose and Stephen Havera are supervising studies of vegetation and wildlife along the Illinois River, including water level tolerances of several species. Inventories of ducks, geese, swans, eagles, herons, egrets, shorebirds, beaver, and muskrats are being expanded and updated.



Aerial photo showing some of the multiple uses of the Illinois River: scenic bluffs to the left are part of Starved Rock State Park, barges and a tug approach the Starved Rock lock and dam from downstream. (Photo by former Survey photographer, W. D. Zehr)

Wildlife researchers are also measuring the contours of the bottomland lakes and sampling and mapping the plants which grow in bottomland forests and mud flats along the river. A lake's contours influence the degree to which increased diversion will flood the adjacent forests and mud flats. Deer, squirrels, raccoons, and other valuable game animals inhabit the bottomland forests, along with ecologically important nongame species. Mud flats provide moist soil food plants for migratory shorebirds and waterfowl, such as pintails, widgeon, gadwall, and teals.

What happens in the Illinois valley is important to the entire state. Natural resources in the river valley include a commercial fishery, bottomland forest, prime farmland, private duck hunting clubs (about 60,000 acres), private goose hunting clubs, nature preserves, natural areas, state parks, conservation areas, and federal wildlife areas. A complete and accurate evaluation of the effects of increased diversion is both economically and environmentally essential to Illinois. The data now being gathered and analyzed should make this evaluation possible.

Soybean Mosaic Virus

Soybean mosaic virus (SMV) occurs wherever soybeans are grown and, from a global perspective, is probably the most common and important virus attacking soybeans. The impact of SMV on soybean yield varies depending on locality, soybean cultivar, and particular strain of the virus. The time of inoculation is directly and positively correlated with yield quality and quantity. Survey entomologist, Michael E. Irwin, and University of Illinois virologist, Robert M. Goodman, both of whom hold joint appointments and postdoctoral fellow, G. A. Schultz, have recently found large

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yield reductions and decreased seed quality in soybeans inoculated with a severe strain of SMV soon after emergence. Later inoculations produced less drastic results.

SMV is transmited from generation to generation through the seed and is spread within and between fields by winged aphids. The only important field sources of SMV are soybean plants grown from infected seed, and the percentage of SMV infected seed in seed lots in central Illinois is very low. Therefore, the amount of primary inoculum available for spread is currently minimal.

Timing and abundance of alate aphids is a critical factor in the spread of SMV. Irwin, and Susan E. Halbert, a graduate student, have found more than 60 species of aphids landing in central Illinois soybean fields each year. Since aphids do not colonize soybeans in Illinois, insecticide sprays are ineffective against field spread of SMV. Only about six of the more abundant species are important as vectors of SMV in Illinois. Irwin has monitored aphid flight activity in soybeans for the past four years. Each year the temporal pattern was distinct and abundances shifted between years.

Because SMV reduces yields and lowers seed quality most severely when it infects soybean plants during early vegetative stages, late spring to early summer flights of aphid vectors are very important to SMV spread.

Although SMV is a limiting factor in soybean production in some areas of the world, it is not currently an important disease of soybean in central Illinois because seed lots have a very low percentage of SMV infected seeds and aphid flights have been sporadic. If aphid flights become heavy and timely for several seasons in a row, this disease could become increasingly more important in central Illinois. Monitoring aphid flight activity and insisting on a minimum standard of acceptance for SMV infected seed in certified seed lots are two ways of helping to predict and prevent possible SMV epidemics in the future.

The work undertaken by this team of researchers has been supported by the International Soybean Program (INTSOY) through the Agency for International Development, an Illinois Agricultural Experiment Station competitive Hatch grant, and the Illinois Natural History Survey.

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NATURAL HISTORY SURVEY REPORTS

NOVEMBER 1978, NO. 181

all Freezing Affects Plant Disease

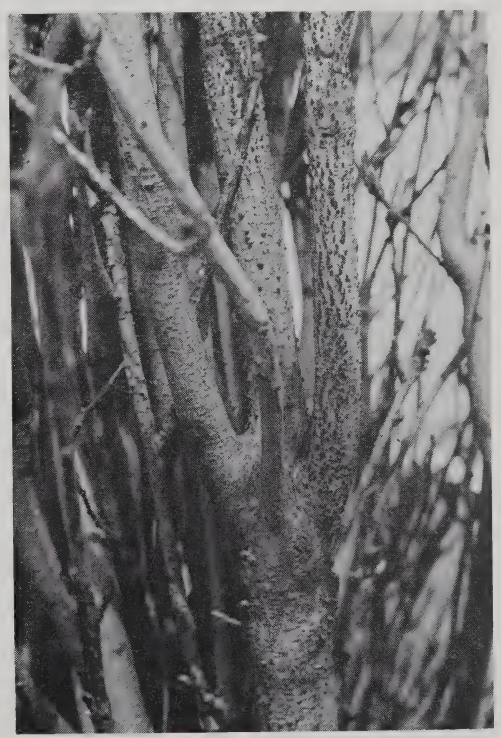
The past two winters in the Midwest set ew records for severity. Are we in for nother bitter cold winter or will we be pared such hardship this year? Unfortuately, the weather in Illinois is unpredictble, regardless of the Farmer's Almanac nd the color bands on the "wooly bear" aterpillars!

Much of the damage caused by the ecord snow, ice, and low temperatures ecame apparent during the past two prings in the form of crumbling highways, urst water and sewer lines, cracked nasonry, etc. A more subtle type of winter amage that few people recognize, however, occurred on many of the trees and nrubs in Illinois. This damage can be seen s an increase in the frequency of certain ypes of plant disease.

Fall temperatures in 1976 decreased eadily to very low levels and the extreme old persisted into mid-February. Extreme ow temperatures, such as the $-20°$ to $-30°$ F readings recorded in January of 977, caused the death of fruit buds, trunk racks on sugar maple and london plane rees, and the death of stems on woody pecies not native to the area and on those n the northern edge of their natural range, uch as sweet gum trees in central Illinois. Most of this damage was due to actual reezing and physical injury caused by ice rystal formation in plant cells. The injury vas apparent at the time of new growth in he spring of 1977.

The winter of 1977–1978 was quite lifferent, as was the effect on woody plants. Temperatures were below normal for most of the fall, winter, and spring but did not reach the extremes of the previous year. However, plant damage was often more severe. The main cause of this extensive damage was a hard freeze to near zero in early December 1977 after an extended period of relatively mild weather.

Trees and shrubs cold harden under slowly falling temperatures and, when fully hardened, may withstand record low temperatures without injury. If hardening is delayed by mild weather, a severe drop in



Basal canker with fruiting bodies of the fungus *Tubercularia* on stems of tallhedge weakened by freezing. (Photo by Dr. D. F. Schoeneweiss)

temperature to below freezing can result in frost collars, bark splitting, and dieback of stems. Even if tissues are not killed, freezing temperatures can weaken stem tissues and cause normally resistant plants to become susceptible to attack by many stem-infecting canker fungi. A sizable increase in the appearance of stem cankers on several tree and shrub species this past spring reflected the freezing stress that occurred from the hard freeze last December.

The dramatic influence of sublethal freezing stress on disease susceptibility of dormant but not fully cold hardened woody stems has been reproduced artificially in controlled freezing experiments by Survey plant pathologist D. F. Schoeneweiss. Plants frozen and inoculated with stem canker fungi that do not attack non-stressed plants showed disease symptoms typical of those observed under field conditions. Unfrozen inoculated plants and plants frozen but not inoculated remained healthy and were indistinguishable from untreated plants.

These results confirm the relationship between freezing stress and many common stem canker diseases and help explain the sudden outbreak of certain diseases, such as basal stem cankers on upright euonymus, tallhedge buckthorn, and red-twig dogwood, that occurred this year.

Unfortunately, little can be done to prevent this type of damage except to plant sensitive species in sites protected from extreme exposure and to avoid practices such as late-season watering and fertilizing or the use of outdoor lighting, which may delay the hardening of woody ornamentals. The appearance of stem canker damage on many woody species should be considered symptoms of stress conditions rather than plant diseases that can be controlled with fungicide sprays.

The Heron Report

The most recently published paper in the Survey's series on Illinois bird populations is *Illinois Birds: Ciconiiformes.* It covers the herons and related species and presents the histories of the Illinois populations, so far as they are known, as well as recent population figures for the various species. The paper also contains quantitative information on migration, nesting, and feeding habits of herons in Illinois. As with all the papers in this series, this one is based on a bibliography of about 7,000 titles, previously unpublished data from numerous contributors, and the field work of Jean and Richard Graber, who compiled the data.

Between 1973 and 1976 an effort was made to locate all the major heron colonies in the state in order to see how well the populations were surviving. Though historical records were fragmentary, the recent census data indicated that heron populations have undergone two kinds of change — (1) a relatively slow long-term decline and (2) a much more rapid recent decline, particularly noticeable in southern Illinois. Possible causes of the population declines are discussed, and areas of further study are recommended in the report.

A serious problem for students of natural populations, and one very pertinent to the herons, is the general lack of information on "normal" fluctuations to be expected from one year to the next. That kind of information is becoming more and more difficult to acquire because the general environment has become so unstable. That instability is exemplified by habitats that are available one year and gone the next, and by food sources clean and dependable in one decade, but in a few short years, dangerously polluted.

There is some evidence that at least the great blue heron and great egret in Illinois are being harassed by hydrocarbon pollution. Egg shells from two colonies on the Mississippi River were very thin by comparison with those of pre-1940 eggs.

An important next step in research on Illinois herons would be comparative studies of the pesticide relationships and productivity of herons in northern Illinois (where populations are surviving better) with those in the south.

Single copies of *Illinois Birds: Ciconiiformes,* Biological Notes No. 109, are available on request. Write to the Chief, Illinois Natural History Survey, 172 Natural Resources Building, Urbana, Illinois 61801.

Adult yellow-crowned night heron, from a drawing by Beverly Sanderson. This bird has a bluish gray body and is about 50 cm tall.

Pelleted Baits for the Black Cutworm

The black cutworm, *Agrotis ipsilon,* is a serious pest in Illinois cornfields, and its attack results in an average of 58-percent loss of plants and a 42-percent loss of yield in some fields. Survey entomologist Ralph Sechriest had found that insecticides in the form of pelleted baits were as effective as sprays in controlling black cutworms in greenhouse and small-plot field experiments. Consequently, he and entomologist Dan Sherrod investigated the effectiveness of pelleted baits under different soil moisture conditions in the greenhouse and as emergency treatments for the control of black cutworm larvae in large field experiments.

Illinois cornfields with natural infestations of third- and fourth-instar black cutworms were selected for the experiments. Commercial formulations of pelleted baits, consisting of standard carrier mixtures of apple pomace, cornmeal, wheat bran, and molasses combined with an insecticide, were used. Baits were broadcast by hand in late May or early June on plots measuring 31 x 31 meters. Pesticide performance was evaluated by comparing the original stand of healthy plants with the number of plants remaining 3 weeks after treatment. Each experiment was replicated three times.

Within the center of each plot, five 15-meter rows, each separated from the others by a row on each side, were staked so that a known number of plants in each plot could be compared. Natural infestations of black cutworm larvae varied greatly, as did plant stand counts, from one plot to another. Thus, comparisons were made between the plant stand counts in the staked corn rows when the treatments were applied and at 1, 2, and 3 weeks after treatment.

The effects of two levels of soil moisture on black cutworm control with pelleted baits and granules were examined in the greenhouse by using wooden flats (plots) with 20 corn plants in each. Treatments equivalent to 1.12 kg of active ingredient per hectare were applied to three replicates of each experiment at the time of planting. Some flats were watered so that the soil surface was always moist, while others were watered only enough to keep the seedlings from wilting. Three fourth-instar black cutworms were released in each flat 3 weeks after planting, and 1 week later two

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fourth- and three fifth-instar cutworms were released in each plot. Counts of healthy seedlings were made at the time of each infestation and 1 week later.

Sechriest and Sherrod found that in the field the standard control practice of applying toxaphene spray as a band over the row was less effective than the broadcast fonofos bait. Carbaryl 5-percent bait and biothion 2-percent bait broadcast at the rate of 0.56 kg of active ingredient per hectare protected corn seedlings as well as the same baits broadcast at double that rate. Biothion 2-percent, carbaryl 5-percent, chlorpyrifos 2-percent, fonofos 4-percent, methomyl 1-percent, and trichlorofon 5-percent baits provided good control of the black cutworm larvae in 3 years of field experiments.

Soil moisture affects the control efficacy of pelleted baits under field conditions. Carbaryl 5-percent bait was found not to have as good residual effectiveness on moist soil as on dry soil in the greenhouse experiments. Some moisture must be present to make the dry pelleted bait acceptable to the larvae, but generally the humidity in the air or a slight dew was sufficient to soften the pellets. In addition, the carriers tend to attract moisture. Since black cutworm larvae typically feed and rest only in moist soil, during extremely dry conditions larvae remain 5–8 cm deep in the soil and may not respond to the pelleted baits. Conversely, moist soil with larvae at or near the soil surface appears to aid control with such baits. This moist soil condition is typical of most Illinois fields when corn seedlings are emerging, and excellent control can be expected under these circumstances.

Damage to seedling corn in the field can range from slight to extensive, and the cutting of 30–50 percent of the plants in a cornfield by black cutworm larvae is common. However, as much as 40-percent recovery or regrowth of cut plants is possible. The closer to the time of seedling emergence the treatments were applied, the greater was the protection provided. The preferred control recommendation by Natural History Survey and University of Illinois extension entomologists is carbaryl 5-percent pelleted bait, and good control of black cutworm larvae has been achieved by Illinois farmers except under very dry conditions.

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NATURAL HISTORY
SURVEY REPORTS

DECEMBER 1978, NO. 182

ʼlail Carrier Pheasant Census

One method employed by biologists to ıonitor the relative abundance and distri- ution of pheasants in Illinois is that of oliciting volunteer assistance of the rural etter carriers in recording pheasants ob- erved while delivering mail. The first ʼural Mail Carrier Census (RMCC) was onducted in Illinois during five consecu- ive days in April in 1958 and has been epeated at five-year intervals. Wildlife bi- logist Richard E. Warner has recently eleased data from the 1978 RMCC which ncompassed the 74 northernmost counties f the state. Self-maintaining populations f pheasants in Illinois are known only in hese counties.

Eighty-eight percent of the 1,178 census ards mailed to rural letter carriers in 1978 vere returned and found usable (89 per- ent were returned and found usable in 1973). A total of 366,005 miles were tallied in 1978, about 15,000 miles more than in the previous count. The number of pheasants observed per 100 miles of driving averaged 0.8 in 1978, compared with 4.9 in 1973, 5.5 in 1968, 9.9 in 1963, and 7.6 in 1958. Thus, the number of pheasants recorded in 1978 represents a decline of 83 percent over the five year period since 1973.

Counties that were among the top 15 in 1973 but are not on this list in 1978 include Macon, McLean, Iroquois, Moultrie, DeWitt, Kankakee, Vermilion, Champaign, Piatt, and Douglass. The northernmost two tiers of counties, broadly classified as a mixed livestock and dairy region, presently rank among the highest with respect to numbers of pheasants counted, a position that has been held in recent decades by the east-central cash grain belt. The top

Cock pheasant in roadside habitat. (Photo by Larry M. David, Department of Conservation)

ten counties are now Macon, Winnebago, Carroll, Lee, Stephenson, Kendall, Woodford, DeKalb, Will, and Ogle. Declines in pheasants observed over the past five years were evident for all of the top 15 counties censused in the 1978 RMCC.

Two factors which have most contributed to the depletion of populations of pheasants from 1973 to 1978 in Illinois have been the continued expansion of row crop farming, resulting in less prime habitat for reproduction, and severe winter weather, particularly where protective cover on the winter landscape is scarce. The RMCC indicated declines of 80 to 96 percent since 1973 in Champaign, Ford, McLean, and Iroquois counties. Declines of this magnitude have been directly attributed to severe winter storms in 1976–77 and 1977–78 on areas in these counties that are monitored as a part of ongoing investigations. Evidence of this sort, in conjunction with the fact that the ringneck presently appears in greatest numbers where protective winter cover is most abundant, as in the northernmost tier of counties, suggests that the decline since 1973 is largely the result of severe storms during the previous two winters.

Malaysian Prawns in Illinois

Aquatic scientists at the INHS and the Urbana campus of the University of Illinois recently were honored by a visit from Dr. Shoa-wen Ling, one of the world's foremost aquaculturists. Following a long and distinguished career in Asia, Dr. Ling is now adjunct professor in the School of Marine and Atmospheric Science at the University of Miami. Dr. Ling is best known as the first scientist to control the life cycle of *Macrobrachium rosenbergii,* the giant Malaysian freshwater prawn, for which he is affectionately acclaimed by his colleagues as the "father" of freshwater prawn culture. The development has great commercial as well as scientific importance because the freshwater prawn has the gourmet qualities of the finest marine shrimp but, once past the larval stage, can be cultured in fresh water. Dr. Ling's visit to Illinois was prompted in part by his interest in the use being made of the prawn at the Kinmundy field station of the INHS, the Sam A. Parr Fisheries Research Center. The work is being conducted in cooperation with the Prawn Aquaculture Program of the State of Hawaii, and the University of Hawaii.

In studies by D. H. Buck, R. J. Baur and associates at Kinmundy the prawns have been incorporated into a polyculture of Asian fishes whose specialized feeding habits are being exploited in the recycling of swine manure. The prawns provide an additional consumer for the uptake of nutrients, the control of eutrophication, the management of wastes, and an additional source of high quality protein. While production of this tropical Asian species will be limited by the short growing season in temperate Illinois, the results at Kinmundy have exceeded expectations. Following an escorted flight from Hawaii, 35,000 of the translucent, inch-long (0.09 gram) prawns were stocked on June 1, 1978, in four experimental ponds. At Kinmundy they received no food beyond that produced in the manure-enriched ponds. Following a period of 131 days, survivors had attained weights averaging 12.7 grams for all ponds, 17.6 grams for the most productive pond. In this best pond 20 percent of the prawns had attained lengths of 4 inches (9.6 cm) or larger as measured from the eye to the tip of the tail, which is market size in many areas where prawns are sold. It was a pleasure to learn, however, that even the smallest of the Kinmundy prawns were a gourmet's delight.

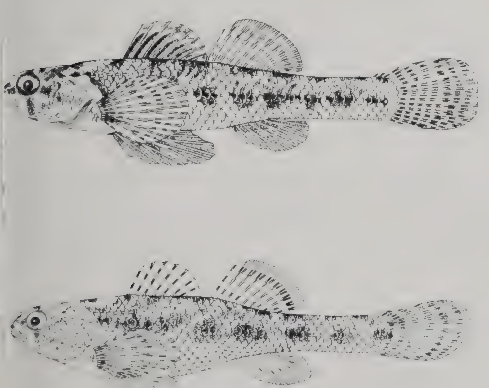
The total production of prawns was at rates of from 250 to 400 pounds per acre in addition to a production of more than one ton of fish per acre. Such high rates of production in temperate waters, with no supplemental feed, and against the competition of native crayfish, suggests the presence of compensating factors. The enrichment by the fresh manure and the abundance of partially-digested plankton (primarily algae) rained down on the prawns in the feces of a large population of filter-feeding fishes must create a milieu rich in organic detritus and both micro- and macro-organisms that is both tasty and nutritious to the omnivorous prawns.

The Cypress Darter

Of the 23 species of darters presently known to occur in Illinois, two are members of the subgenus *Microperca* (meaning small perch) and are among the smallest fishes in the United States. One of these, the cypress darter, *Etheostoma proeliare*, reaching a maximum adult size in Illinois of only 36 mm (1.5 inches) in length, was the subject of a life history study recently published by former Survey ichthyologist B. M. Burr and Survey ichthyologist L. M. Page. Copies of this publication, *Biological Notes No. 106*, are available upon request to this agency.

The cypress darter is found in leaf-laden and/or vegetated sluggish streams and margins of lakes and is distributed throughout the Coastal Plain province in the lower Mississippi River valley. One year of field and laboratory observations were made on a population in Max Creek, Johnson County, Illinois. In contrast to other darter species that have been the subjects of life history studies in Illinois, the cypress darter is shorter-lived (maximum of 18 months), much smaller in size, and has indented eggs that are in the shape of half-donuts rather than being spherical.

At one year of age the cypress darter spawns in vegetated or debris-laden pools. One to three eggs are laid at a time on leaves of aquatic plants, on algae, or on the sides of rocks. Laying eggs on leaves, undersides of rocks, etc. requires that the spawning pair assume vertical and inverted positions. The male mounts the female and expanded cuplike webs of skin on his pelvic fins allow him to grasp and hold onto the back of the female during spawning. Eggs are left unguarded by the parents and hatch in about nine days at 20°C. Growth is rapid during the first eight weeks. The cypress darter feeds principally on small crustaceans and immature aquatic insects.



Breeding male (upper) and breeding female (lower) of the cypress darter. (Drawings by Allice A. Prickett)

Life history studies contribute greatly to our knowledge of a species and its overall place in the environment and often reveal information useful in determining relationships to other species. The indented, half-donut shaped eggs and the pelvic-fin flaps found on breeding males are unusual, highly derived attributes of the cypress darter and indicate that the species is among the most highly specialized of all darters. Future studies at INHS will continue to concentrate on poorly known fishes for which information is much in demand by persons conducting environmental studies, students, and naturalists.

Dimorphic Protozoans

One of the many problems facing biologists involved in the classification of animals or plants is the occurrence of morphologically or biochemically different forms within a single species. Unless the dimorphic or polymorphic nature of the species is understood, the different forms are often described as several different species while these are, in fact, only variants of a single dimorphic or polymorphic species.

Such dimorphic species of microsporidia were the topic of a recent paper by Survey entomologists, J. V. Maddox and R. K. Sprenkel. Microsporidia are tiny Protozoan parasites primarily of insects. They are obligate parasites which infect the insect hosts either orally by ingestion of the resistant spores or transovarially via the eggs. Several hundred species of microsporidia representing 38 genera have been described from insects. Most of these microsporidia form only one type of spore depending on the genus to which they belong. However, some of the microsporidia studied by Maddox and Sprenkel produced two spore forms; one having characteristics of the

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genus *Nosema* and another having characteristics of the genus *Thelohania*. If the insect host is reared at 32°C or higher only *Nosema*-type spores are produced, but at lower temperatures both *Thelohania*-type and *Nosema*-type spores are produced. Both the *Nosema*-type and *Thelohania*-type forms were previously described as two separate species.

Among the methods used to prove that these forms were dimorphic forms of the same species, Maddox and Sprenkel used a density gradient technique to mechanically separate the two forms. When fed to susceptible hosts the *Thelohania*-type spores produced only *Nosema*-type at 32°C, while the *Nosema*-type spores produced both *Nosema*-type and *Thelohania*-type spores at lower temperatures. Maddox and Sprenkel also theorized that, since only *Nosema*-type forms are found at 32°C, if this were a mixture of two species, continuous passage through susceptible hosts at that temperature should eliminate the *Thelohania*-type form. However, the percentage of *Thelohania*-forms remained relatively constant during passage through eight hosts at 32.2°C.

Most of the *Thelohania* species described from lepidoptera occurred as mixed infections with *Nosema* sp. and many of these are probably single dimorphic species. These findings suggest that dimorphism may be common among the microsporidia infecting lepidoptera and extreme care should be exercised before mixed infections are described as two separate species.

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NATURAL HISTORY
SURVEY REPORTS

JANUARY 1979, NO. 183

Weed-Eating Insects as Biological Control Agents

The purslane sawfly has been observed to cause considerable destruction to common purslane and was thought to be a possible biological control agent for this weed. Survey extension entomologist Roscoe Randell and University of Illinois Department of Horticulture researchers S. F. Gorske and H. J. Hopen conducted tests to determine whether the purslane sawfly feeds exclusively on common purslane and what effects some commonly used pesticides have on the purslane sawfly.

Common purslane is a weed that is not destroyed by normal cultivation practices. Once uprooted, purslane is capable of sending out adventitious roots and reestablishing itself.

Some purslane sawfly larvae mine out the contents of the leaf; another race feeds externally on the leaves.

One characteristic of an effective biological control agent is that it feeds only on the organism that it helps to control. If the weed plant is not present, the insect that helps to control it must not feed on other plants of economic importance.

Before a proper field management program can be established, it is necessary to know which pesticides are toxic to the control-agent insect under study. Several pesticides commonly used in Illinois vegetable fields were selected for tests on the purslane sawfly.

In the field studies, screen wire cages were placed around each weed to be tested and were set 5 centimeters deep into the soil to prevent the escape of the larvae. Larvae of the externally feeding and leaf mining types were collected, and three larvae of each type were placed in each cage. In each test, each experiment was replicated several times.

The testing of various plants as possible food sources of the purslane sawfly was also carried out in the greenhouse. Each plant to be tested was placed in a pot. Three larvae of each of the two feeding types were placed in each pot and a screen wire cage was placed over the pot.

Of the 17 plant species tested in the field, the purslane sawfly larvae fed only on common purslane.

Greenhouse studies of closely related plants showed a broader range of host plants. The purslane sawfly deposited eggs and fed on common purslane, and it developed normally on winter purslane. When seedlings of winter purslane were grown in the greenhouse, adult purslane sawfly females flew in through an open vent and deposited eggs on the leaves. The eggs and larvae developed normally, and the larvae fed only on the winter purslane.

Eight pesticides were selected for tests, including three insecticides, carbaryl, malathion, and *Bacillus thuringiensis;* three herbicides, DCPA, trifluralin, and nitrofen; and two fungicides, chlorothalonil and maneb. Externally feeding larvae were collected for this study, and 10 larvae and five purslane leaves were placed in a petri dish for each test. Each pesticide was applied to the leaves and larvae at one-tenth of the recommended rate for field use, at the recommended rate, and at 10 times the recommended rate. A plain water spray was used as a control test.

Carbaryl and malathion caused almost immediate and complete mortality of the sawfly larvae at all application rates. Of the sawfly larvae feeding on common purslane treated with *Bacillus thuringiensis,* 50 percent died from the recommended field rate, and the higher rate gave complete mortality. Direct application of the herbicides DCPA, trifluralin, and nitrofen at the recommended field rate or higher killed all of the larvae.

The fungicides chlorothalonil and maneb produced little or no mortality at or below the recommended application rate. The highest rate of application resulted in 100 percent and 95 percent mortality rates, respectively.

In the tests involving pesticides applied to the soil, purslane plants were planted singly in pots to which 10 larvae of the externally feeding type were added. A screen wire cage was placed over each pot. Three days after the sawfly larvae pupated, the herbicides DCPA and trifluralin were applied to the soil at the same three rates used in the foliar application tests. After the herbicides were applied, water was used to wash the herbicide into the soil.

The herbicides applied to the soil had no effect on the sawfly pupae, the cocoons preventing the herbicides from making contact with the pupae.

Other researchers have found that biological control of weeds is best accomplished by the use of insects on perennial weeds in range lands or other areas not under cultivation. Common purslane, an annual weed growing in intensively cultivated areas, does not fit that model. The Survey and University researchers concluded that the purslane sawfly has the potential of providing good control of purslane late in the growing season in cultivated areas and complete control earlier in the season in areas not under heavy cultivation or pesticide application. Control by the sawfly should be part of an integrated control program in which the major components are the use of selective herbicides and cultivation. Pesticides to control other pests might best be applied during the period when the sawflies are pupating.

Yellow-wood: A Forgotten Tree

Yellow-wood, *Cladrastis lutea,* a member of the bean family (Leguminosae), is native to the eastern United States and is one of our rarest trees. Survey botanist Ken Robertson recently published a review of the yellow-wood (single copies available on request). The species occurs in 12 states, primarily in the southern Appalachian highlands (Great Smokey Mountains, Cumberland Mountains, Cumberland Plateau) and the Ozark Plateau (Boston and Ouachita mountains) with a number of outlying populations, including Alexander County, Illinois; Brown County, Indiana; Brown County, Ohio; and Aiken County, South Carolina. Nowhere is the tree common. Wild yellow-woods usually are found on cliffs along river systems or in openings of moist coves in hardwood or hemlock forests. Because of its scarcity (there are fewer than 100 wild yellow-woods in Illinois), it is being considered for the official lists of threatened and endangered species of the United States and of Illinois.

Yellow-wood is one of the most beautiful flowering trees native to eastern North America. The tree is hardy throughout much of eastern North America, including most of Illinois, and is sometimes cultivated in parks, on campuses, in botanical gardens, and less often, in yards. In winter, the tree is attractive because of its gray, beech-like bark. In late spring, a yellow-wood tree in full flower is truly spectacular. In summer, the rounded crown, medium textured foliage, and short trunk make the yellow-wood a nice landscape tree. In autumn, the foliage turns a beautiful yellow.

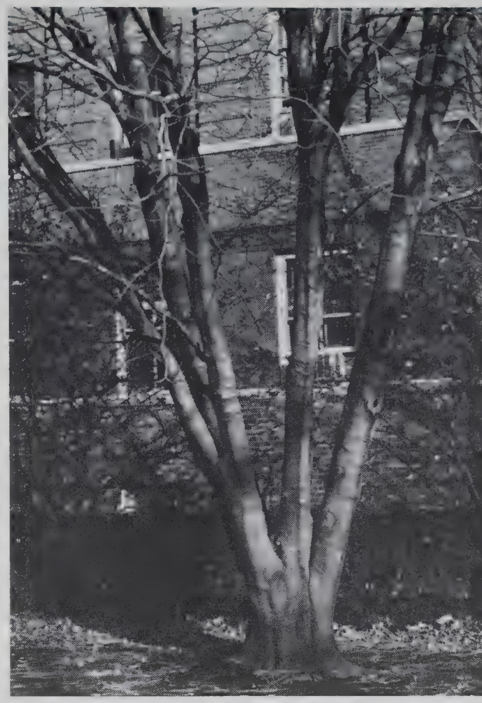
However, yellow-wood should probably not be used for mass planting, but is best suited to the patient gardener, since the species takes 10 to 20 years to flower from seed. Individual trees flower heavily only every second or third year, and the species is difficult to purchase from commercial nurseries. A number of fine specimens of yellow-wood are in cultivation on the University of Illinois campus, in the Morton

ellow-wood tree in summer. (Photo by K. R. Robert-
›n)

ırboretum at Lisle, in the Missouri Bo-anical Garden in St. Louis, and in the Chicago Horticultural Society Botanical Garden.

The genus *Cladrastis* is of interest to otanists because of its distribution, with *C. lutea* in the eastern United States and our additional species in eastern Asia. This ype of distribution indicates that the genus s an old one and once had a much broader istribution. As a result of the periods of laciation, the genus was locally extermi-ated over much of its range, leaving relict opulations only in eastern Asia and east-rn North America. The present distribu-on of *C. lutea* reflects this history. Plant eographers theorize that the species oc-urred over much of North America during ne Mesozoic but survived the Pleistocene laciations only in areas that escaped inun-ation by glaciers or shallow seas. Follow-ng glaciation, the species expanded its ange somewhat, particularly along certain najor river systems, such as the Kentucky nd White rivers. For some reason, how-ver, the species has not been able to nigrate into areas once covered by glaciers. ince the only Illinois population of yellow-vood occurs in an area that was not glaci-ted, it is possible that it represents a pop-lation that survived the glaciers.

Yellow-wood trees in cultivation are gen-rally not troubled by diseases or insect ests. The branches are rather brittle and he crotch of the trunk is weak, making ellow-woods, particularly old ones, sus-



Trunk and main branches of yellow-wood tree in winter. (Photo by K. R. Robertson)

ceptible to wind and ice damage. Although the cultivated yellow-woods in Illinois are generally healthy, the wild trees are not, and many of them have dead or dying branches. The reason for this decline is not known, but may be due to diseases or insect pests, to the inability of the species to compete or persist under the present environmental conditions, or to past disturbances in the forest. Further studies are needed to ascertain the nature of this problem.

Trends in Cottontail Abundance

In November 1978 Survey biologists conducted roadside censuses of cottontails in the vicinity of Sibley, Ford County, and Neoga, Cumberland County, that further document the decline of cottontails in prime agricultural areas. These censuses followed the routes and procedures used by Survey biologist William R. Edwards for a similar census in November 1962.

In 1962 on the Sibley area, cottontails were counted on six evenings along 552 miles of rural roads, with 268 rabbits observed — 48.6 per 100 miles of driving. At

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Neoga in 1962 a total of 269 rabbits was seen on seven evenings along 545 miles of roads — 49.4 per 100 miles. During the 1978 census at Sibley, cottontails were counted on five nights along 450 miles of roadside, with only seven rabbits observed — 1.6 per 100 miles. This density represents a decline of almost 97 percent in the number of rabbits seen at Sibley between 1962 and 1978. At Neoga in 1978 cottontails were censused on six evenings over a total of 468 miles, with 29 rabbits sighted — 6.2 per 100 miles. This density represents a decline of about 87 percent in the number of cottontails observed at Neoga.

By comparison, counts of cottontails observed on summer roadside pheasant brood censuses at Sibley by Richard Warner and his predecessors at the Survey show 26.9 cottontails observed per 100 miles in 1962 compared with 2.2 rabbits observed in 1978 — a decline of 92 percent. Previously, Survey biologist D. Russel Vance (1976) reported a decline of cottontails from 5.1 flushed per 100 hectares censused on the Hunt Area in Jasper County in 1939 to 0.2 flushed in 1974 — a decline of 96 percent. Vance associated the decline of cottontails to drastic changes in habitat and land use at Hunt.

There can be little doubt that popula tions of cottontails in Illinois, particularl in prime agricultural areas, have bee drastically reduced over the past 20–3 years.

Allerton Park, Piatt County, represen a situation where habitat has been rela tively stable and minimally affected b changes in agriculture. Cottontails hav been censused on the 4-H Area at Alle ton Park in late October or early Noven ber for the past 23 years. Trapping i November 1978 indicated a population 136 cottontails using the 4-H Area. A though the 1978 estimate was well belo the estimate of 259 for 1977 and the pea estimate of 358 obtained in 1976, it wa well above the estimate of 97 obtained b Edwards in 1962 and the mean estimate 104 for the 4 years, 1962–1965. The 2 year mean estimate for the 4-H Area 206 cottontails, with a range from 88 1965 to 358 in 1976.

The drastic long-term decline of cotto tails in agricultural areas apparently is du in part to changes in land use and farmi practices. In contrast, the cottontail pop lation in the undisturbed habitat at Alle ton Park appears to have remained rel tively stable.

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NATURAL HISTORY SURVEY REPORTS

FEBRUARY 1979, NO. 184

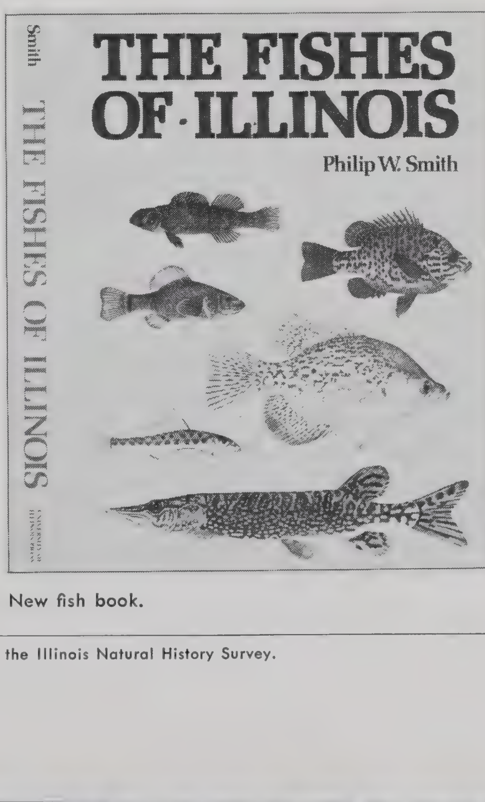
ishes of Illinois

Among the responsibilities assigned by ıw to the Illinois Natural History Survey re "to conduct a natural history survey of ıe state" and "to publish, from time to me, reports covering the . . . zoology and otany of the state." The most recent of ıch reports is a book released in January ntitled *The Fishes of Illinois* by Survey :hthyologist P. W. Smith. This report, hich has superb color illustrations of 34 pecies, was published, and will be distrib-ted solely, by the University of Illinois ress, 54 East Gregory Drive, Champaign, linois 61820. The post-publication price $20.00, but it is available to readers of ıe *Illinois Natural History Survey Reports* : a 20 percent discount, making the total ost $16 plus a $1 postage and handling ıarge and 5 percent sales tax for Illinois sidents.

Smith and his associates spent 11 years ollecting in various aquatic habitats ıroughout Illinois and in adjacent areas f bordering states. Some six years were pent in office research, writing the text, ıd preparing the illustrations. The paint-ıgs were done by Mrs. Alice Ann Prickett f the University's School of Life Sciences ıd usually depict males in breeding colors ıade from living but anaesthetized fishes.

The fish book treats the 199 species that ccur, or did occur, in the state. A sepa-ıte chapter for each family headed by the ommon and scientific names describes the ımily, its relationships, and economic im-ortance. A key to genera follows with a aragraph briefly mentioning the content f each genus and how many of its species occur in Illinois. Each species account contains the common and scientific name, a synonymy of the names used in the Illinois literature, a diagnosis, a discussion of variation and subspecies, a summary of the ecology of the species, and a statement of its former and present distribution.

There are 185 black and white illustrations and 196 distribution maps. Each map indicates the distribution of the species prior to 1908 and, by a different type symbol, that at the present time. For the many species whose status has changed during the 75-year interval, the probable reasons for the changes are identified. The book also contains illustrated keys for identifying all Illinois species, a discussion of the history of ichthyological research in the state,



New fish book.

an extensive literature cited section, and a glossary. It has been anxiously awaited by biologists for more than 10 years.

Seventy Years Later

It is now more than 20 years since the second series of statewide censuses of bird populations was conducted in Illinois. The first censuses, conceived by Stephen A. Forbes in recognition of the need for quantitative data to understand ecological relationships, were started in 1905 by Alfred O. Gross with the help of fellow student Howard Ray, under Forbes' direction. The study was carried on intensively through 1909 and provided a population record probably unmatched anywhere in the world. Part of the data were published by Forbes and Gross between 1907 and 1923, and Gross left all of his original field notes at the Survey for further evaluation. Alfred Gross later became a renowned professor of biology at Bowdoin College. With his encouragement and advice and the Survey's support, Survey biologists Drs. Jean and Richard Graber carried out a similar series of censuses from 1956 through 1958.

In the 50 years between the censuses some interesting changes occurred, but overall the Illinois avifauna had remained remarkably intact. It was fortuitous that the second series of censuses came when they did, on the brink of enormously rapid change in the habitats of Illinois. Included among the changes were vastly increased use of insecticides and herbicides and great changes in habitat availability. Illinois has changed more in the past 20 years than it did in the previous 50 years. Although the Grabers have been censusing forest areas the past 5 years using the Forbes-Gross technique, in 1978 they started work on other habitats, the ultimate goal being to determine what is happening to bird populations in these times of such rapid change.

Even though the same technique can be used, one important change has been forced upon the census takers. The earlier censuses covered the various habitats in a random sequence as they were encountered on cross-country transects. Ample samples of most of the habitats were eventually acquired in this way, including even the rarer habitats such as marsh and ungrazed grassland. Now, random transects would be unlikely to encounter the rarer habitats and the investigators must seek out such habitats in the few places they still exist. That change complicates the interpretation of the data, because there is no way to determine whether the surviving tracts of habitat differ in important ways from the habitat in general. The investigators have no choice in the matter. If any data are collected on certain habitats, such as marsh, the investigators must census what is left.

Yellowheaded blackbird on cattails in a northern Illinois marsh (photo by Jean Graber).

Herbert H. Ross

Dr. Herbert H. Ross, former principal scientist, assistant chief, and head of the Section of Faunistics and Insect Identification, died in Athens, Georgia in November, 1978, at the age of 70. Dr. Ross retired from the Survey in 1969 after more than 40 years of service. He took a teaching position at the University of Georgia from which he retired in 1975.

One of the most respected scientists in North America, Dr. Ross published 220

erbert Holdsworth Ross.

ientific works, including 7 books and hapters in 6 other books. He was active n several scientific organizations and erved as president of the Entomological ociety of America (1954–55), the Society or the Study of Evolution (1966–67), and he Society of Systematic Zoology (1973–4).

A memorial fund has been established n Dr. Ross's name to support systematic esearch in entomology at the University of llinois and the Illinois Natural History urvey. Readers who knew Herb Ross and vould like to provide a lasting tribute to is memory can make a contribution to his fund. Checks should be made payable o the University of Illinois and marked for he Herbert H. Ross Memorial Fund. Please send contributions to the University f Illinois Foundation, 224 Illini Union, Jrbana, Illinois 61801.

rop Pests of 1978

Extension entomologists in the University f Illinois and the Natural History Survey nd other extension specialists held the hirty-first annual Custom Spray Operators Training School at the University on January 9, 10, and 11. Entomologists Kevin Black and Gary Braness presented information on the 1978 insect situation and insecticide usage, and also on the outlook for insect conditions in 1979. Much of the information regarding the ranking of the insects and estimation of insecticide usage in Illinois was compiled from reports submitted by county extension advisers.

Of the common insect pests of field crops in the state only corn rootworms declined significantly. This decline was caused by late planting of corn, a factor which helped promote black cutworm problems. Black cutworms were ranked by county extension advisers as being second only to European corn borers in terms of damage, amount of pesticides applied, and numbers of calls for assistance or information which were received in the county offices. Grasshoppers were ranked by advisers as the third worst insect pest in Illinois. Grasshopper populations have been steadily increasing over the past few years and many fields of both corn and soybeans were damaged in 1978.

Other agricultural insects which were considered especially bad this past year included corn earworms, bean leaf beetles, stored grain insects, rootworm beetles, and fall armyworms. Alfalfa weevil problems were reported from occasional fields of alfalfa in northern Illinois, an unusual situation since damage from this insect normally occurs only as far north as Peoria. Another unusual situation was a corn borer infestation in a field of first-trifoliate-stage soybeans in Jasper County.

Prediction of insect problems for 1979 is difficult at best. Black cutworm infestations are highly dependent upon spring weather, weed conditions, planting date and other factors. Likewise, European corn borer infestations are highly weather dependent. The amount and type of fall and spring tillage, as well as planting date, greatly affect resulting populations of borers. Because of the tremendously high fall generation of corn borer populations in Illinois in 1978, conditions for 1979 should be regarded as threatening. Grasshoppers are also likely to be a problem again in 1979 if

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weather during the early summer egg hatch is relatively dry. Cool wet weather during the egg hatch could greatly reduce grasshopper damage potential.

Rootworm populations, which were greatly reduced between 1977 and 1978, are likely to remain relatively stable. The number of rootworm beetles laying eggs in 1978 suggests no large increase in populations for 1979. Populations of other insects such as alfalfa weevils, corn earworms, fall armyworms, etc. are nearly impossible to predict.

Growers can greatly improve their chances of getting maximum yields if they will frequently inspect their crops for developing insect problems. Should problems or questions arise, the entomologists of the University Extension Service and Natural History Survey are always willing to help.

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NATURAL HISTORY SURVEY REPORTS

MARCH 1979, NO. 185

lfalfa Weevil Hunt

Attempts to control the alfalfa weevil ith fall insecticide applications have not lways been successful. Alfalfa weevils go nto aestivation, a torpid or dormant state nduced by the heat and dryness of sumner. Economic entomologists R. J. Barney, . J. Roberts, R. D. Pausch, and E. J. rmbrust recognized the need for information about when alfalfa weevil aestivation nds, when the weevils return to alfalfa elds, and the timing of their dispersal and ubsequent egg laying throughout the elds. It is believed that some alfalfa eevils aestivate in woods bordering alfalfa elds. Therefore, the entomologists conucted a study in Washington County in outhern Illinois, where many wooded field orders serve as aestivation sites for alfalfa eevils.

The study site was a 24-acre alfalfa field ounded on the north by soybeans, on the outh by corn, on the west by a road and orn, and on the east by woods. Four alalfa weevil sampling methods were used: mergence traps, flight traps, sweeping ith nets, and collecting egg samples.

Each emergence trap covered an area of square foot, and they were designed so hat any insect or other active organism merging beneath the trap was collected n a jar. The six emergence traps were laced in the woods along the border of the lfalfa field. Each trap was checked peridically, and any alfalfa weevils were renoved and recorded.

Each flight trap was a rectangular box upported by a metal pipe. A sheet of clear lexiglas was positioned 30 degrees forward of vertical above the box to deflect any flying organisms into ethylene glycol contained in the box. Four flight traps were placed in the alfalfa field 40 feet from the woods and facing the woods. During periodic checks any alfalfa weevils were removed with an aquarium dip net and recorded.

A standard 15-inch-diameter sweep net was swung across the tops of alfalfa plants to locate weevils within the field. Five sets of 50 sweeps were made at five evenly spaced intervals across the field, the first set near the wooded east border of the field and the fifth set near the west side. The

The termination of alfalfa weevil aestivation and the pattern of reentry into a field have been studied by Survey entomologists. (Photo by former Survey photographer W. D. Zehr)

number of adult alfalfa weevils was recorded for each set of sweeps on every sampling date.

Each egg sample consisted of a one-quarter square foot area of alfalfa removed with a knife and placed in a plastic bag. The alfalfa was ground in a blender and washed through a series of screens to reveal the alfalfa weevil eggs. Five egg samples were collected at each of the five locations where net sweeps were made. Egg samples were collected until the average daily temperature was below the threshold of development for the alfalfa weevil (48° F.).

The entomologists found that not all alfalfa weevils ended their aestivation at the same time. The emergence traps revealed two peaks of activity. A small group of weevils appeared in the traps in early September, while the majority were found in mid- to late October. More than 300 acres of alfalfa were in the area surrounding the study field, and some growers were forced to cut alfalfa before the optimum time. Other researchers have suggested that cutting alfalfa earlier than usual in the spring, which results in much higher ground temperatures than would otherwise be encountered, may initiate alfalfa weevil migration from the alfalfa to aestivation sites. This early initiation of aestivation by a minority of weevils may result in an early termination of aestivation by these same weevils, perhaps explaining the emergence in early September.

The flight trap catches showed that alfalfa weevils moved into the field about a week after emerging from their aestivation sites. However, the flight traps caught only a small number of weevils, possibly indicating that more flight traps should have been used or that they were placed at an incorrect height or distance from the field border. Another explanation may be that weevils reentered the field by short flights or simply by walking, which would not be detected by the flight traps.

The sweep-net data revealed a large adult weevil population in the field 3 weeks after their emergence at aestivation sites. Once the weevils end their aestivation and begin to reenter the alfalfa field, a feeding period at the edge of the field may be necessary before they disperse throughout the field. Sweeping the field at five locations showed that field reentry was a gradual process, beginning at the wooded field border. In late October more than 50 percent of the alfalfa weevils were located near the wooded border. By mid-November the weevil population was well dispersed throughout the field.

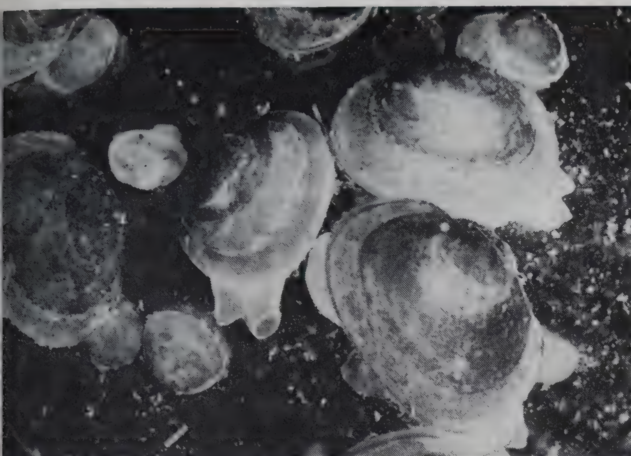
The data from the egg samples demonstrated the same gradual field dispersal. On 1 November almost 60 percent of the weevil eggs were found along the wooded edge of the field. By mid-November egg density was uniform throughout the field.

The termination of alfalfa weevil aestivation and the pattern of reentry into a field may be different for various areas because of the availability of aestivation sites, the timing of spring alfalfa cutting, and climatic conditions. Data will have to be gathered for local areas to predict accurately the best time for fall application of insecticides as a part of an integrated pest management program.

Fingernail Clam Bioassays

Before 1955 fingernail clams were abundant in the Illinois River. In that year, for some reason still unknown, fingernail clams died out in the Illinois, and they have never recolonized the areas where they formerly lived. These clams are used for food by diving ducks, such as the canvasback and lesser scaup, and by some bottom-feeding fish. The use of the river by diving ducks and the condition of bottom-feeding fish have declined as a result of the fingernail clam die-off. The demise of the fingernail clam in the Illinois River contributed to the decline of the commercial fishery there, and the remaining commercial fisheries on the Mississippi River are dependent on fishes that feed on fingernail clams.

Research has been in progress for some time at the Survey's Illinois River Laboratory, using an apparatus which exposes fingernail clams collected from the Mississippi River to raw Illinois River water treated to remove suspected toxicants. Survey aquatic biologists Richard Sparks and Michael Sandusky expect to learn, by a



Fingernail clams, formerly abundant in the Illinois River, died out there in 1955 and have never returned. They are an important food source for diving ducks and some fish. (From a color transparency by Dr. R. E. Sparks)

rocess of elimination, which factors in Illinois River water prevent fingernail clams rom recolonizing the river. The results of his research could also be used to prevent he die-off of fingernail clams in the Mississippi.

Testing has been impeded because of quipment failures, contamination of Illinois River water by metals leaching from he intake system, and the failure of some atches of fingernail clams to grow well or urvive under laboratory conditions. However, steps have been taken to solve these roblems, and research progress is being nade.

Culture tests have shown that after 4 veeks the survival of fingernail clams in etri dishes containing silt is much better han it is in petri dishes without silt. The growth rate of clams is also slightly better n silt. Therefore, fingernail clams will be naintained in silt during subsequent bioassays.

Some of the mortality in fingernail clam cultures maintained in the laboratory is attributable to leeches that prey on the clams. These leeches are introduced in the sediment which accompanies the clams when hey are collected from the Mississippi River. Consequently, the clams may have o be handpicked from the sediment before they are placed in culture tanks, and he sediment used as a substrate in the tanks may have to be sterilized by heating.

These experiments may eventually unlock the secret of why fingernail clams died out in the Illinois River, and they may also point the way to cleaning up the water so that fingernail clam populations can be reestablished in the Illinois.

Sandhill Crane Migration

In cooperation with the University of Wisconsin and the U.S. Fish and Wildlife Service, Survey wildlife biologists William W. Cochran and Arlo Raim studied the fall migration of sandhill cranes from the interlake region north of Winnepeg, Manitoba, where these birds breed, to their wintering grounds on the Texas coast. Raim devised two radio transmitter designs for mounting on the leg band normally used by wildlife researchers for marking this species. One of the designs was conventional, being powered by batteries for a predicted life of 1 year. The other used photocells to provide an indefinite period of operation. A total of 12 transmitters was constructed. The Canadian Wildlife Service placed the transmitters on nestlings in late July.

Personnel from the University of Wisconsin and the Canadian Wildlife Service monitored the birds as they dispersed from their breeding area to southern Manitoba and North Dakota, where they spent the last part of August and all of September. Cochran went to North Dakota in early October, prior to the migration of the sandhill cranes, to instruct personnel from the University of Wisconsin in the techniques used for following migrants. One

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bird, in a flock of about 500, was followed to a wintering area for the species southwest of Houston, Texas.

These birds turned out to be easy to follow because they travel slowly and make their migratory flights during the same period each day (from 1100 to 1730 hours).

Cochran's interest was in the possibility for observing the homing phase of this migration during which the birds were expected to alter their generally southward course to seek out their specific wintering areas. It was expected that a rather abrupt change would be noted about the time the birds reached the latitude of their goal.

The cranes' flight was almost due south for the first 800 miles (this took 4 days) after which the flight distance covered per day was reduced to about 80 miles and the flight direction became rather unpredictable. Flight was generally to the southeast, south, or southwest, seemingly dependent upon wind direction. However, during the last half hour to hour of flight each day, the direction shifted to almost straight east or west. During this period, the flock size (the number of birds with the radio-equipped bird) was reduced gradually to about 200 birds and, finally, to about 70 birds.

These observations suggest that experienced members of the flock search out familiar landmarks during the latter portion of the migration, with flock breakup due to differing goals. If this is the case, this species is a poor one for definitive studies of orientation and navigation mechanisms.

The principal objectives of the study were to evaluate habitat use during migration and to field test the technique and train personnel for a follow-up study of the endangered whooping crane in 1979-1980. The study will be continued with the spring migration of the sandhill cranes already radio tagged (and later, the whooping cranes) by researchers from the University of Wisconsin.

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NATURAL HISTORY SURVEY REPORTS

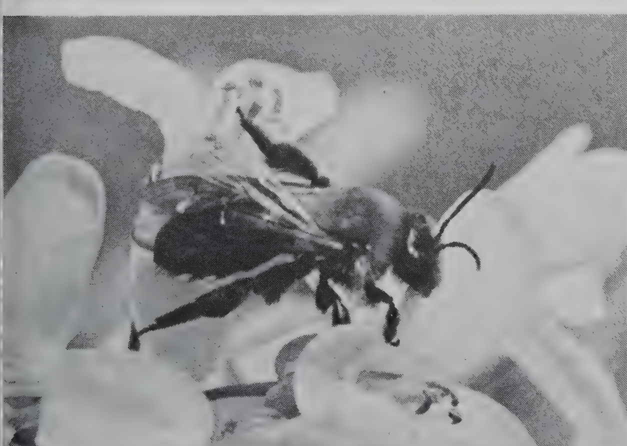
APRIL 1979, NO. 186

ee Systematics — Melandrena

The genus of bees known as *Andrena* cludes nearly 500 species in North Amer-a and as many or more in the Old 'orld. Many of these bees are important ›llinators of fruit crops such as straw-:rries, blueberries, apples, pears, plums, ıerries, and native plants such as sun-›wers. Survey entomologist W. E. LaBerge ıd several associates have been studying e systematics of the North American ›ecies of *Andrena* for several years. These udies are being supported in part by nds from the National Science Founda-›n, and they are a prelude to a faunal udy of the bees of Illinois.

Systematic studies have several purposes nong which are: to make known the fferent kinds of organisms, to make ıown their valid scientific name, to name :rms that have not been named, to pro-de illustrations and keys so that other ientists can identify the species, to de-ribe their variation, geographical distribution and habits when known. It is frequently of practical importance to be able to accurately identify species. For instance, if a scientist were studying pollination of apple trees in northern Illinois, he would have to be able to recognize *Andrena thaspii,* a bee important in apple pollination. However, there are three or four other species of *Andrena* which may be active in northern Illinois at the same time as *Andrena thaspii* and which are very similar in appearance to *thaspii.* These other species do not visit apple tree blooms or do so only infrequently. Without a carefully constructed key, illustrations, and descriptions, no one would be able to make the critical distinctions between these species of *Andrena,* and the scientist may spend considerable effort studying the wrong species. Also, the valid scientific name of a species is the indispensable key to all previously published information regarding that species.

The ninth part of the revision of the



Andrena (Melandrena) carlini resting on flowers of toothwart (Photo by Joseph Laury Luth).

bees of the genus *Andrena,* describing a group of species known collectively as the subgenus *Melandrena,* was recently completed by Survey entomologists John A. Bouseman and Wallace E. LaBerge. This study was based upon over 12,000 specimens which segregate into 22 species. The species of *Melandrena* are spring or early summer bees, and several are important pollinators of fruit trees and berries. One common fruit tree visitor, previously without a name, was named *Andrena illini* by Bouseman and LaBerge because it is common throughout the state of Illinois.

Coal Conversion Wastes

With the shrinking of the world's petroleum resources, energy planners are taking a fresh look at the nation's energy sources, especially coal which represents a large percentage of our energy resources. Coal gasification and liquefaction are two methods by which coal can be converted to synthetic gaseous and liquid fuels. However, the conversion of coal is not without environmental impact. The amount of solid waste produced by a single coal gasification plant over 20 years is estimated to occupy 1,250 acres to a depth of 10 feet. The disposal of these huge amounts of waste is unprecedented and successful commercial production of these fuels will partially depend on the "safe" disposal of their wastes. Survey aquatic biologists John J. Suloway and William F. Childers in conjunction with members of the Illinois State Geological Survey have been investigating the impact of leachates generated from coal conversion wastes on the aquatic environment in a study funded by the federal Environmental Protection Agency.

The four phases of the project included examining the mineralogy of the coal solid wastes, the solubility of chemical constituents of the waste, the attenuation of leachates by the soil, and the toxicity of leachates generated from coal conversion wastes to aquatic organisms. Suloway and Childers were primarily involved with the toxicity testing. The primary objectives of the toxicity tests were to determine: a) if coal conversion waste leachates were acutely toxic to young fathead minnows, b) ho much dilution was necessary to elimina mortality caused by a leachate during 96-hour test and c) which water solub chemical constituents were responsible f the toxicity.

Ninety-six hour static bioassays of th leachates were conducted with one to si day-old minnows, *Pimephales promela* Small, young fish were used since it w occasionally difficult to obtain large quan tities of solid waste from which leachat could be generated. For example, Illino coal had to be shipped overseas to be pr cessed at a power plant in Scotland i order to obtain coal gasification ashes. Th bioassays were conducted under controlle conditions in an environmental chamb where the temperature was maintained a 21 (± 1)C and there was a constant pho toperiod. Approximately 14,000 minnow were utilized in bioassays of 88 leachates.

Approximately half of the natural leach ates were acutely toxic to young fathea minnows under laboratory conditions. Sev eral acidified leachates were very toxi and required large amounts of dilutio (> 1:100) to ensure survival during a 96 hour bioassay. The extent of a leachate' toxicity and the amount of dilution neces sary to ensure survival during a 96-hou bioassay were largely a function of acidit and total ion concentration. Some of th leachates contained potentially hazardou concentrations of aluminum, chromium copper, magnesium, nickel and zinc. Sulo way and Childers plan to continue thi research in order to study long-term effect of these leachates and the effects of these leachates on other aquatic organisms.

Illinois River Timber

Several hundred acres of bottomland forest exist in the floodplain of the Illinoi River on islands and along the shoreline of the river and its associated backwater lakes. The majority of the bottomland timber occurs along the lower two-thirds o the river from the Great Bend, near Hennepin, to Grafton. One aspect of the Lake Michigan Diversion Project was to assess the effects of increased water levels on the

ottomland forest, chiefly silver maple, near Rice Lake, Illinois (Photo by Steven P. Havera).

oral and faunal species comprising the ottomland forest community of the Illiois River.

During the fall of 1978, wildlife biologist tephen P. Havera and associates Donald teffeck, Fred Paveglio, and Kathleen rcher sampled 15 tracts of bottomland mber between Hennepin and Grafton, nd gathered such data as species composiion, basal area, density, tree size (DBH), nd the monetary lumber value of the timer.

By combining these field inventories of ie bottomland tree species with their tolerances to various water conditions as eported in the literature, the possible ffects of increased water levels on the mber of the Illinois River can be assessed.

A total of 18 tree species were tallied in ie timber cruises. Silver maple, cottonood, and species of ash were found in all 5 tracts of timber sampled; elm species 1 14 of the tracts; willow, hackberry, pean, and sycamore in about half of the udy areas. Box elder, river birch, honey ocust, red mulberry, basswood, hawthorn, in oak, persimmon, sugarberry, and swamp privet were found in 25 percent or less of the tracts.

The basal area of the bottomland timber stands sampled varied from 95 to 173 sq. ft. per acre. In all of the 15 stands, silver maple accounted for the majority of the basal area, with an average of 64 percent of the total basal area for all 15 areas. The density of bottomland trees varied from 95 to 304 trees per acre among the study areas. The area with the smallest density of trees (95 per acre) was near Meredosia. This tract also had the largest trees inventoried with an average diameter at breast height (DBH) of 25.8 inches. The remaining timber stands had average DBH values between 12.2 and 17.9 inches.

The number of board feet was calculated from the number of sawlogs tallied for each tree species on the study areas. Utilizing the most recent Illinois timber prices, an estimated value of the lumber could be derived. The value for sawtimber in bottomland stands sampled varied between \$254 and \$595 per acre. These estimates should be considered as maximum amounts. The stand with the highest sawlog value

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per acre was in Sanganois State Park at the confluence of the Sangamon and Illinois rivers.

Perhaps the most impressive timber stand sampled was at Godar's Swamp near Kampsville. Here large pecan trees accounted for 30 percent of the basal area. Some of these pecan trees had DBH's of 36 inches. A good population of large cottonwood trees and a fair number of pin oaks were also present.

Timber from four of the 15 tracts sampled had been harvested within the last 5 years. Because of selective timber cutting and agricultural encroachment upon bottomland areas, pecan and pin oak stands once prevalent along the southern reach of the Illinois River are being transformed to stands dominated by silver maple.

Insect/Plant Relationships

The practical implications of how insects select plants upon which to feed and how plants evolve to avoid being eaten justify research efforts in this field. Recently, entomologist Marcos Kogan published a paper summarizing information on insect/plant chemical interactions in which he suggests several basic models in the host-selection processes followed by various insects.

About half of all known species of insects are more or less dependent on plant host Generalized feeding, or polyphagy, seem to be a primitive stage in insect/plant in teractions and oligophagy (few plant hosts the rule among plant-eating insects. Th information available on host-selectio processes is based on few insect/plant rela tionships. Only 18 plant families out c about 320 existing families of higher plan have had representative species investigate in this way. As these studies expand t include other plants and insects, addition models will be recognized.

These insect/plant associations involv sensorial, physiological, and ecological pro cesses mediated by many factors. There i little doubt, however, that plant allelo chemics are the key factor in the establish ment of the associations. The identificatio of the chemical bases of host-plant selec tion by insects and of host-plant resistanc to insects can greatly improve the efficienc of programs for breeding resistant varietie of plants. It can also open new avenues fo the manipulation of insect's behavior fo use in pest management programs.

Although the practical aspects of in sect/plant asociation studies are obviou the scientific knowledge to be gained o the interdependence of organisms an their harmonic coevolution makes suc studies especially exciting and attractive.

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NATURAL HISTORY SURVEY REPORTS

MAY 1979, NO. [illegible]

'he Persistence of Benomyl 'n Walnut Fruit

, The severity of anthracnose leaf spot on lack walnut, a major disease of this tree pecies, causing premature defoliation, reuced growth, malformed nut meats, and ossible tree death, has recently been found) be reduced by applications of the fungiide benomyl. Successful treatments have een made through leaf spray and soil inection methods. The ability of this fungiide to control many other pathogens has een well documented since its introducion in 1967. Benomyl is a systemic fungiide that moves through a tree's vascular ystem from one part to others.

Researchers have shown that MBC, the table product formed when benomyl is uspended in a water-based medium, can ave long-lasting effects on disease develpment for up to several years after soil pplication. Foliar applications have also esulted in MBC residue accumulation in he xylem tissue, but its movement to other plant parts is slow and for the most part restricted to areas about the point of application.

In both leaf spray and soil treatments, the prime site for MBC accumulation is in the foliage. Scientists elsewhere applied benomyl sprays to the external surfaces of oranges and detected residues in the juice for up to 84 days after treatment. The persistence of benomyl on exterior surfaces, acting as a reservoir for its subsequent systemic movement into the plant over long periods of time, is an obvious asset to its use in curbing disease.

Because of the systemic nature of benomyl and the uncertainty of its movement, particularly into floral parts and fruits, plant pathologists Dan Neely and Steven Cline decided to determine the persistence of benomyl on and in walnut fruit when applied as foliar sprays, as trunk infusions, and by soil injection.

The ability of benomyl to persist on nut hulls was found to be a function of its con-

Black walnut trees are now a plantation crop. The tree in the center has been extensively defoliated by anthracnose.

centration. The spray concentration normally used on walnut plantations lasted about 5 weeks, when more than one-half of the inhibitory effectiveness was lost, as measured by bioassays. Spray treatments two and four times the normal concentration lasted longer, but all foliar spray treatments were 97–98 percent ineffective at inhibiting the test fungus 2½ months after treatment.

Soil and trunk injection results suggested the possible uptake and translocation of benomyl (MBC) to nut hulls when some of the bioassays displayed sensitivity after 48 days. These data, however, do not appear significant and require additional testing.

Correlations between benomyl residue persistence on nut hulls and amounts of precipitation, both in the field and under simulated rainfall in the laboratory, indicated an interaction. At test sites at Urbana, Carbondale, and Fisher, rainfall of 5–7 inches accompanied a decrease in benomyl effectiveness of 80–90 percent. At the Martinsville test site, however, more than 5 inches of precipitation fell, but no marked change in bioassay results appeared. Laboratory rain bioassay experiments demonstrated the ability of benomyl to remain effective after 24 inches of precipitation. These results indicate that other factors may be involved in the ability of benomyl to persist on nut hulls.

Nut meat tests resulted in a lack of detectable benomyl residue. A more sensitive testing method is now being sought for the detection of smaller fungicide amounts than can be detected through bioassays.

Abundance and Migration of Woodcocks

The date of arrival of woodcocks in central Illinois in 1978 is not known. However, on March 15 Survey Biologist Charles M. Nixon observed a male exhibiting what is believed to be territory-establishing behavior, called "displaying," on snow-covered ground along the Vermilion River south of Danville.

Wildlife Specialist William R. Edwards and his associates are studying the woodcock to learn more about how to manage it as a living natural resource. They estimated that 38 woodcock territories were active through May on the Forest Glen Nature Preserve, also along the Vermilion River and on lands immediately adjoining the preserve. Peak numbers of woodcocks were observed during June at Forest Glen, but woodcock sightings declined in July and August. Woodcocks were observed almost every evening, but in much reduced numbers, in late August, September, October and early November. Where 15–20 birds might be seen on an evening in June, only 2–4 might be seen in late summer. Single birds were seen on November 17 and 21, the last to be observed at Forest Glen in 1978.

On November 11, the opening day of the 1978 upland game hunting season in Illinois, hunters reported flushing unusually large numbers of woodcocks over much of central Illinois. Examination of weather data indicated the southeasterly passage of a frontal system through Wisconsin on November 5 and through Illinois on November 6. Rainfall was quite general in Illinois on November 6 behind the front. Following the passage of the front in Wisconsin, the barometer was relatively high, temperatures were low, and winds were out of the north and northwest — conditions basically favorable to woodcock migration. The investigators concluded that probably there was a major woodcock migration out of Wisconsin on the evening of November 6 and that migration ended when the birds caught up to the rain in central Illinois. As a result, large numbers of woodcocks were present in Illinois on November 7.

On the assumption that southward migrations proceed on the basis of high pressure systems and southerly or southeasterly movements of air following the passage of frontal systems, the next weather conditions favorable for a major migration of woodcocks out of Illinois took place during the period of November 19–21. No woodcocks were observed at Forest Glen after November 21.

Weather in Illinois in January and February 1979 was much colder than normal, and snowfall was much above

rvey wildlife specialists are studying the abundance and migration of the woodcock in Illinois. The bird own here was injured when it flew against a large picture window.

ormal. The passage of the first major arm front of 1979 occurred on March 2. emperatures in the 50's occurred on [arch 3–4. Rainfall was general in Illi- ois on March 4 with winds out of the uth. On March 4 Nixon again observed woodcock near the Vermilion River, and [s. Marilyn Campbell, naturalist for the orest Glen area, reported a woodcock at was seen on March 4 in nearby West- lle. On the evening of March 5 the orest Glen area was censused for the first me in 1979, and woodcocks were found splaying on or near all territorial sites sited that had been occupied in 1978 and several locations that were not regularly sed in 1978.

Here again was a pattern of woodcock igration associated with the passage of a ontal system followed by a wind favor- ole to the direction of migration and ap- arently terminating with rainfall. The orthward migration was associated with warm front, whereas the southward mi- rations of November 1978 were associated ith cold fronts. In their continuing in- estigations the researchers expect to learn ore about woodcock abundance and mi- ration patterns.

Even the Bugs Have Bugs

The alfalfa ecosystem, unlike many other field crops, represents a relatively long lasting, well-established perennial system. Thus, it serves as a natural nursery for many predators, parasites, and pest species which may eventually migrate to neighboring annual crop systems, such as soybeans. Many pests of the order Lepidoptera, whose larval forms are caterpillars, are commonly found on soybeans and alfalfa, and some are serious pests of both crops. To control insect pests of field crops through integrated pest management programs, it is necessary to know which parasite species occur naturally in pest species at each stage of their lives. Entomologists Stephen Roberts, W. K. Mellors, and Edward Armbrust decided to research the relationships of parasites and lepidopterous larvae in soybeans and alfalfa to understand more fully the importance of parasites as biological control agents.

In the first growing season of this study, 10 soybean and 5 alfalfa fields were sampled, and in the next season, 14 soybean and 8 alfalfa fields. Larvae were collected with a standard 15-inch sweep net; the entomologists made 200 sweeps per field

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at about 1-week intervals. The larvae that were collected were reared on suitable artificial diets or on fresh alfalfa leaves. The rearing continued until adult Lepidoptera emerged, parasites emerged, or the larvae died from unknown causes. The percentage of parasitism was calculated for pest species.

Ten species of lepidopterous larvae were collected in Champaign County in the two growing seasons. These species, with the percentages (in parentheses) that were attacked by parasites in alfalfa and soybeans, were the green cloverworm, *Plathypena scabra* (43.3 and 32.4); the celery looper, *Anagrapha falcifera* (38.2 and 37.9); *Autographa precationis* (no common name) (the population was too small to determine percentages of parasitism); the variegated cutworm, *Peridroma saucia* (34.1 and 46.7); the alfalfa caterpillar, *Colias eurytheme,* and the clouded sulphur, *Colias philodice* (these two species were not separated because of the possibility that they may hybridize and because it is difficult to identify species of larvae in the genus *Colias*) (47.0 and 47.0); the forage looper, *Caenurgina erechtea* (9.7, and the population in soybeans was too small to determine the percentage of parasitism in the yellowstriped armyworm, *Spodopte ornithogalli* (36.0 and 40.6); the arm worm, *Pseudaletia unipuncta* (21.4 ar 52.8); and the yellow woollybear, *Di crisia virginica* (24.0, and the populatic in soybeans was too small to determine tl percentage of parasitism).

All of these species of lepidopterous la vae were collected in both alfalfa and so beans in both growing seasons, except f *A. precationis,* which was not collected soybeans in the second season. A total 27 parasites, including two hyperparasit that attacked some of the parasites, we found in the host species. All parasites ar hyperparasites were identified as to genu and all but two were identified to specie

Possibly as a result of the influence pathogens and parasites or both in comb nation with other factors, the seasonal a erages of most of the lepidopterous larva collected were less than one per 100 swee of the collecting net for both years in bo crops. Only the green cloverworm and tl *Colias* species had averages of more tha one per 100 sweeps in one or both crop Undoubtedly the parasites played a part controlling these pest populations.

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NATURAL HISTORY SURVEY REPORTS

JUNE 1979, NO. 188

quirrel Nests

Both gray and fox squirrels use tree oles for shelter or construct nests of leaves nd twigs in trees. A nest in a tree cavity hould be warmer and more protected than ne made of leaves or twigs and, likewise, est boxes ought to be comparable to tree oles. If this hypothesis is correct, squirrels intering in nest boxes should be in relavely better physical condition than those intering in leaf nests.

Survey wildlife biologists C. M. Nixon nd L. Hansen compared the percentage f carcass fat for male fox squirrels colected from nest boxes with male fox quirrels from leaf nests in late February 978 in Vermilion County, Illinois. These iologists also evaluated the use of nest oxes by fox squirrels by collecting data on ne physical environment surrounding each est box. Some 27 variables such as height of box from ground, tree species, number of escape trees, and direction of box entrance were used in an analysis of their effect on the use or non–use of nest boxes.

Nixon and Hansen found that male fox squirrels from nest boxes did not have significantly more fat than those from leaf nests. Only two physical factors were found to be important to the use of nest boxes by fox squirrels. There was a positive relationship between box height above ground and box use and a negative relationship between number of existing tree holes in the nest box tree and squirrel use of that box. Thus, to maximize use of a nest box by fox squirrels, nest boxes should be placed as high in a tree as possible and should not be put in a tree with an existing cavity.

Another method of enhancing squirrel populations is by retaining some large trees with cavities when timber is harvested.

Gray squirrel (Photo by Larry Farlow, former Survey photographer).

Wildlife biologists Nixon and Hansen counted all trees with a diameter at breast height (dbh) of 5 inches or greater on 63.5 acres of forest to determine which species of trees produced most tree cavities and in what size of tree were these cavities most likely to be found. Three species of trees — sugar maple, basswood, and beech — contained significantly more cavities than expected, and white and black oaks and hickories contained fewer cavities than expected from their abundance in the forest. A majority of trees with cavities were larger than 12 inches dbh. The retention of 2 to 4 maples, basswood or beech trees per acre during selective harvesting of timber in a hardwood forest should provide squirrels and other cavity nesting wildlife with sufficient nesting sites with little loss of valuable timber.

Collections and Collectors

An extremely valuable resource at the Natural History Survey is the systematic collections of plants and animals. Many scientists are well aware of them and make almost constant use of them, but the general public may not have given much thought to the value of collections that date back a century or more ago. They have been used primarily for research and reference (direct comparison for identification purposes) rather than for public display, but today with the intense interest in baseline data for environmental impact statements they are proving to be a goldmine of information on environments of the past. They provide a picture of what Illinois habitats were like at almost any given period during the past 100 years, what organisms were present, and even something about the relative abundance of these plants and animals.

While serious studies of plants in the State predate those of animals, the material collected and reported upon was not deposited at the Survey. The earliest specimen in any of the collections is a remarkably well-preserved sturgeon collected in the Ural River of Russia by a Dr. Lewzerow in 1862 and apparently sent to Survey scientists in a specimen exchange. A few fish and insect collections made in Illinois during the 1870's are extant, ar many specimens of fishes, various kinds insects, amphibians, and reptiles, taken the 1880's, are in remarkably good co dition.

Most of the study specimens in th Survey's collections were made by sta members, who in a sense were monitorin the environment by their collecting pr grams over the years. As the fame of th collections grew, it was inevitable th private collections would be donated to th Survey for safe keeping. Among the anim groups more than 50 major collectio have been deposited here. The earliest fo which we have a record consists of appro imately 6,000 beetles and bees given to th Survey in 1881. The most recent were la year when a private collection of 20,80 mussels from Illinois rivers was presente some 10,000 vials of caddisflies, ants, an scorpion flies were bequeathed, and mo than a quarter of a million pinned insec were transferred to us on permanent loa by the University of Illinois. All stud specimens have complete collecting data

The outstanding collections at the Su vey are those of insects with over fou million specimens and fishes with about half-million, but other small collection represent fungi, flowering plants, mollusks spiders, and other vertebrate groups. special collection consists of soybean-asso ciated arthropods from all parts of th world where soybeans are grown. It an some of the other noninsect groups ar being computerized in order to facilitat rapid retrieval of valuable data. The refer ence material is the official State collection and one of the responsibilities of thi agency is the proper maintenance of th collections.

Thrips in Soybeans

The soybean thrips, *Sericothrips vari abilis,* is commonly found in soybean field throughout the Midwest and it approache pest status in Illinois for the first time i 1975 when numbers reached epidemic pro portions. The stress exerted by thrips o soybean seedlings, especially in the souther third of the state, was compounded b stress caused by herbicide injury. As leave

seedlings curled and dropped, farmers ecame concerned and began treating with secticides. Within the major zone of in- station about 1.5 million ha (hectares) of ybeans were planted. Of those, over),000 ha were treated with insecticide to ntrol soybean thrips. At the time of the utbreak, little was known about the soy- ean thrips and their impact on soybean uality and yield. Some species of thrips re known to be involved in the transmis- on of bud blight disease of soybeans, aused by tobacco ringspot virus. This dis- ase can dramatically reduce soybean seed uantity and quality. Survey entomologist I. E. Irwin began a study of thrips in ybean fields in 1975 and has discovered me facts that could lead to an improved nderstanding of the role of thrips in soy- ean production in Illinois.

Under laboratory conditions Irwin and . E. Halbert, a graduate student, have nown that the soybean thrips is probably ncapable of spreading bud blight disease o soybeans. A study was initiated between rwin of the Illinois Natural History Sur- ey and the University of Illinois, K. V. Yeargan, University of Kentucky, and V. L. Marston, United States Department f Agriculture, Missouri, to determine the pecies composition and the spatial and emporal distribution patterns of thrips in oybean fields in the Midwest.

Two species of phytophagous thrips — he soybean thrips, *Sericothrips variabilis,* nd the flower thrips, *Frankliniella tritici* — colonized soybean plants in the area. Numbers of thrips were similar no matter vhich part of the fields were sampled. However, both species were unevenly dis- ributed on the soybean plants. Larvae and dults of the flower thrips were concen- rated in terminal buds and blossoms. Adults of the soybean thrips were found nost commonly on the uppermost fully expanded leaf or on the leaf immediately below it. Larvae of the soybean thrips were generally concentrated on the 3rd–6th eaves below the terminal. Both species occurred in soybean fields throughout the growing season. Populations of the flower thrips peaked earlier than did those of the soybean thrips. Early season population densities of both species were higher, and rates of population buildup and decline were more pronounced in Kentucky than in either Illinois or Missouri.

Moderate infestations of certain species of thrips early in the growing season may be economically beneficial. Preliminary results strongly suggest that the density of *Orius insidiosus,* an important general insect predator, in soybean fields is directly correlated with buildup of colonizing thrips. After thrips population levels are suppressed by the predator, *O. insidiosus* seems to act as a buffer to the buildup of other soybean pest species because it preys on their eggs and small larvae. Irwin is currently studying the interaction of thrips and *Orius* in soybeans with the thought that a better understanding of these two major groups of insects in soybean fields could be used to help reduce pest problems throughout the growing season.

Computers at the Library

LCS is the new acronym being used at the University of Illinois Library. It stands for the Library Circulation System, which is now computerized. As a departmental library of the University of Illinois, the INHS Library has a computer terminal that is wired directly to the data base containing the shelf list of the entire U. of I. Library. It can be searched by author, title, author–title or call number. If the work being searched is located in the library system, the terminal prints out its call number, author, title, place and date of publication, location, circulation period, and whether it is charged out, has saves on it or is on the shelf ready to circulate.

If the book a researcher needs is located in the main library or another departmental library, it can be charged out to him/her remotely on the INHS Library terminal. The book can then reach the researcher in one of three ways: (1) the researcher can wait a few hours and go pick it up at its location, where it will be waiting; (2) it can be sent to the INHS Library through the shipping department of the U. of I. Library; or (3) it can be mailed to the researcher through campus mail.

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The INHS Library computer terminal is also wired to be used with an acoustic coupler to reach literature data bases through long–distance telephone lines. The University of Illinois Library subsidizes searching on BRS) Bibliographic Retrieval System), which contains data bases such as Biosis Previews (publishers of Biological Abstracts and Bioresearch Index), Agricola or Cain (National Agriculture Library), Dissertation Abstracts, Pollution Abstracts and National Technical Information Service. These data bases can be searched very reasonably with the U. of I. Library subsidization. Royalty data bases cost $10 per half–hour on–line and non–royalty data bases are only $3 per half–hour on–line. Back files can be searched off–line at night when the data bases are unavailable for on–line use. The citations retrieved in this way can be printed on–line the next day at the on–line rate or mailed to the Library at the rate of 16¢ per page. Most of the data bases contain citations to literature from about 1970 to the present. This makes them very valuable as a fast literature search for fairly current citations in many subject areas.

BRS is a relatively new vendor and has at this time fourteen data bases for searching. Two of the data bases useful to INHS researchers that are not offered by BRS are Commonwealth Agriculture Bureaux an Aquatic Sciences and Fisheries Abstract Consequently, the INHS Library also ha a password and account number wit DIALOG, the Lockheed Information Sys tem.

In the near future the University of Illi nois Library will be closing its card catalo and replacing it with a full-bibliographi record on–line. This record will be search able by every access point, if not more, a the current card catalog, i.e., author, title subjects, junior authors, series, corporat affiliations. This data base will be search able in each departmental library, includ ing INHS, as well as many librarie throughout the state.

Computers are great aids in getting th right material to the right person at th right time, and will most likely becom more so in the future. With the cost o printing on paper increasing so rapidly, w may find publishers of both primary liter ature and secondary literature (abstractin and indexing services, bibliographies) mak ing more use of on–line services and les use of printed products. In twenty t twenty–five years we may find scientifi research institutions, such as INHS, par ticipating in what Dr. F. W. Lancaster o the U. of I. School of Library Science call "the paperless society."

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NATURAL HISTORY SURVEY REPORTS

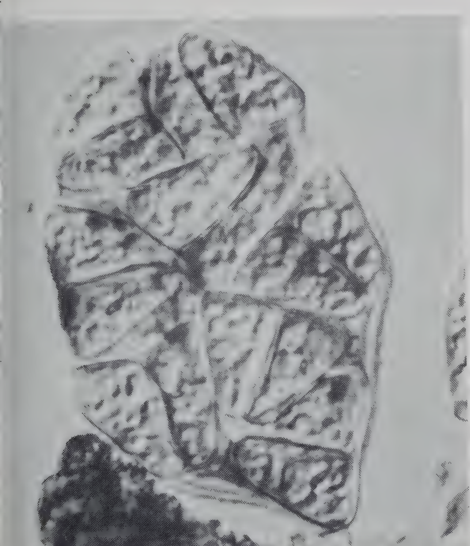
SEPTEMBER 1979, NO. 189

Newly Discovered Fungus

During an investigation of the fungi that ther on plant debris in cypress swamps Illinois, a new fungus of the class Ascoycetes was found by mycologists J. L. ane of the Illinois Natural History Sury and C. A. Shearer of the University Illinois. This fungus has a closed sporearing structure (cleistothecium) and o-celled, brown, butterfly-shaped (papilaceous) spores, called ascospores, conned in asci, or spore sacs. It is referred as CS-470. The mycologists will describe is new species in a new genus in the subss Loculoascomycetes.

The fruiting bodies, which produce ores, are solitary and lie on or near the rface of the material on which the fungus lives, or are embedded in or sunk below the surface, and are globose. The asci are bitunicate (two-walled), globose to somewhat globose, and stalked and lack a subapical chamber. The papilionaceous, two-celled, brown, smooth-walled ascospores uniquely characterize this species. Of the Ascomycetes with bitunicate asci, CS-470 fits best in the Order Pleosporales because of its middle-sized pseudothecia, persistent pseudoparaphyses, septate brown spores, and occurrence on dead twigs.

CS-470 appears to be a rare species that occurs in warm seasons. It was found only once in collections made monthly from three cypress swamps over a 2-year period, and this occurrence was in August 1974. It was collected again in August 1977 in



ewly discovered fungus, CS-470. At the left is the bitunicate (two-walled) ascus (spore sac) magnified 793 mes. At the right is the mature butterfly-shaped ascospore magnified 1,833 times.

the same cypress swamp from which it had been collected originally.

Although CS-470 was collected from submerged wood, fruiting bodies developed on the wood after it was incubated in a moist chamber. In addition, submersion of the fungus culture was not necessary to induce fruiting. Even though this behavior is typical of a number of freshwater, estuarine, and marine Ascomycetes, more information is needed about the distribution of this species before it can be characterized as a freshwater Ascomycete.

Managing Waterfowl Habitat Along the Illinois River

The Illinois River valley is one of the nation's most important areas for migrating waterfowl. Long ago, hunters recognized the abundance of waterfowl in the bottomland lakes of the valley, and in the 1890's sportsmen began to acquire bottomland property for the purpose of forming "duck clubs." However, the prohibition of baiting in the mid–1930's greatly reduced the duck kill by private clubs in the Illinois Valley. Although the navigation dams bui on the Illinois River in the late 193 increased the natural food resources f waterfowl, it became necessary for duc clubs to control water levels on their pro erties to maintain high quality huntin Water levels are now manipulated by mar private duck club and public waterfov areas.

Water manipulation permits duck foo plants to be sown or to volunteer on mu flats during the summer and then allov them to be flooded with water during th fall to attract migrating waterfowl. E 1941, 432 (55 percent) of the 792 duc clubs in Illinois were located in the Ill nois Valley. During the late 1950's an early 1960's, thousands of acres of aquat duck food plants were lost in the valle as increasing sedimentation and turbidit filled shallow productive areas and cloude the waters of the bottomland lakes. As result of this degradation, the managemer of water levels by duck clubs and state an federal agencies is now almost mandator if high quality hunting is to be enjoyed.

Aerial view of land belonging to a private duck club north of Spring Bay, Illinois. Naturally occurring mois soil plants are grown in the irregularly shaped area in the center foreground. Corn is grown in the othe fields. The annual harvest of ducks in the Illinois Valley ranges between 50,000 and 100,000.

The number of waterfowl hunting areas ong the Illinois River, their sizes, and anagement practices were investigated wildlife specialists Frank Bellrose and ephen Havera and other members of e Wildlife Research Section at the Hana Laboratory as part of the Lake ichigan Diversion Project that proposes increase the amount of Lake Michigan ater that is diverted into the Illinois iver.

The Illinois Department of Conservaon issued licenses to 272 duck hunting ubs that managed land along the Illinois iver during 1977. In September 1978, a uestionnaire was sent to 219 duck clubs iat owned 40 acres or more along the linois River. A total of 160 (73.1 perent) of the clubs responded, representing 7.3 percent (51,405 acres) of the total rea managed by licensed duck clubs in ie Illinois Valley. Water levels could be ontrolled on almost 32 percent (16,315 cres) of the total area managed by the ubs responding to the questionnaire.

The U.S. Fish and Wildlife Service and ie Illinois Department of Conservation wn 50,478 acres containing 24,344 acres f water in the Illinois River valley. Water evels can be managed on 14.6 percent 7,388 acres) of the total area.

In addition to impoundments where vater levels can be controlled, thousands f acres of publicly and privately owned vaterfowl areas rely on naturally occurring ow water levels during the summer for he establishment of moist-soil vegetation such as smartweeds, rice cutgrass, wild nillet, and beggar ticks) and the planting f agricultural duck foods. Also, sections f federal, state, and private duck-hunting ands are refuge areas where no hunting nd little disturbance is permitted during he waterfowl season.

Of the private clubs that responded to he questionnaire and that control water evels, 18 percent managed exclusively for natural moist-soil food plants, whereas 24 percent managed for agricultural crops. Both natural and agricultural food management occurred on 58 percent of the private clubs with water level control. Japanese millet was the most common agricultural crop planted by private duck clubs (59 percent) followed by buckwheat (58 percent), corn (46 percent), soybeans (2 percent), rice (1 percent), and milo (1 percent). State and federal agencies planted primarily Japanese millet, corn, and buckwheat.

State, federal, and private areas control 90,829 acres that are used primarily for waterfowl hunting and management, representing approximately 43.2 percent of the 210,000 acres of nonleveed floodplain in the Illinois Valley. The remaining 190,000 acres of the floodplain are in levee and drainage districts primarily for agricultural purposes.

New Concepts on Black Cutworm Field Biology

The black cutworm, *Agrotis ipsilon,* is a cosmopolitan insect that attacks at least 49 species of field and vegetable crops. The larval or worm stage of this insect is dark brown to black and is approximately 2 inches long and about pencil thick. The larvae cause damage by severing seedling plants or chewing into stalks, roots, bulbs, and tubers. These worms are especially damaging to corn throughout Illinois during May and early June. The complete life history of this insect is not known for the north-central region of the United States, and no criteria have been available for predicting infestation and damage.

During the growing seasons of 1974

Black cutworm larva found beneath a chickweed plant in a field before crop planting time.

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through 1977 a total of 38 corn fields damaged by the black cutworm were intensively studied by economic entomologists Dan Sherrod, John Shaw, and W. H. Luckmann. Two new concepts concerning the field biology of this insect resulted from these studies. The first concept is that black cutworm larvae damaging seedling corn in May and June originate from eggs oviposited in the field in the spring before the corn is planted. By collecting and sizing larvae from the study fields and applying predictive techniques based on temperature data, they determined a theoretical oviposition date. In almost every case the predicted oviposition date preceded the planting date for each field. These larvae that hatch prior to corn emergence must have some source of food until the corn is available. They found that spring weed plants growing in the field could fill this need.

This point forms the second concept: agronomic practices which encourage the establishment of weeds, especially winter annual and perennial weeds, increase the potential for the presence of the black cutworm. In 1976-1977 fields that had a history of problems with black cutworms were monitored by regularly visiting the fields from February through May in an attempt to detect infestations before corn planting time. Larvae were observed in April and May around clumps of common chick weed, *Stellaria media,* and mouse-eare chickweed, *Cerastium vulgatum vulgatum* Usually, one or more larvae could be re covered by digging in the soil around th base of a chickweed plant. In Illinoi chickweed is classified as a winter annua which germinates and establishes itself i the fall. It grows during the winter an flowers in late February and in March Chickweed and other winter annuals ar most likely to occur in fields where soy beans were grown in the previous year an where the soil has not been disturbed o has been disturbed in a minimal wa through conservation tillage.

The proposed concepts are based on th best data currently available. The blac cutworm is a difficult pest to predict, an considerable additional information on cut worm biology and behavior and on fiel ecology will be needed before good detec tion and control programs can be refined The concept on the significance of weeds i very applicable to conservation tillage sys tems often used for corn following soy beans. Weediness also increases in th spring due to extended periods of rainfal when fields cannot be timely prepared an planted. The concept that the larvae tha damage seedling corn are in the field be fore the seed is planted reflects the realit of field observations and field problems.

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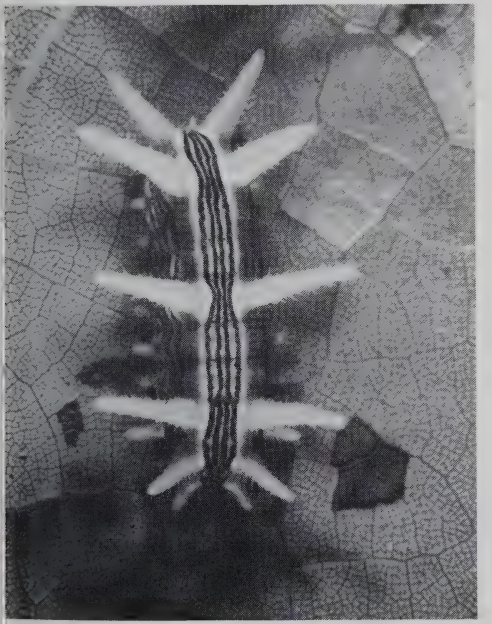
›tinging Caterpillars

The concern of people when they en-ounter caterpillars feeding on garden ›lants, trees, and field crops primarily ocuses on the economic or aesthetic dam-ge that the caterpillars may cause. They arely are considered as potentially and lirectly hazardous to human comfort. The ast majority of caterpillars brought to he Illinois Natural History Survey for dentification are various species of cut-vorms and armyworms. These can be afely picked up with bare fingers, and he most that the handler may anticipate s being nipped by the caterpillar's man-libles. Unfortunately the same cannot be aid of stinging or urticating caterpillars that can cause reactions ranging from mild itching and stinging sensations to a variety of more serious symptoms, for example inflammation of lymphatic tissue, that may be accompanied by considerable pain and swelling of extremities.



tinging rose caterpillar (*Parasa indetermina*) on a eaf (Photo by Les Woodrum, Survey Photographer).

Several species of urticating caterpillars occur in Illinois. Examples of them include the larva of the io moth (*Automeris io*), the puss caterpillar (*Megalopyge opercularis*) and about 20 species of slug caterpillars. Many urticating caterpillars feed on a variety of cultivated shrubs and trees, but frequently go undetected. The ones most likely to attract the attention of the curious gardener or horticulturist are some of the slug caterpillars because of their bright, gaudy coloration.

Slug caterpillars belong to the lepidopterous family Limacodidae. Their slug-like appearance is caused by a retracted and partially concealed head, inconspicuous thoracic legs, and abdominal prolegs that are vestigial or absent. As a result slug caterpillars seem to glide rather than walk. Some of the species are smooth and lack tubercles or spines while others such as the rather common saddleback caterpillar (*Sibine stimulea*) and the stinging rose caterpillar (*Parasa indetermina*) bear prominent fleshy tubercles that are covered with numerous spines.

Neither the relative toxicity of each species of slug caterpillar nor the nature of the toxin has been documented adequately. It is known that the spines on the body of slug caterpillars contain a substance that is released when the spines pierce and break the skin of an unsuspecting person. Not all reactions are chemi-

cally caused because some species of urticating caterpillars bear types of setae or hairs that contain no toxin but instead are minutely barbed and can mechanically cause irritations.

There is no reported outbreak of slug caterpillars and other urticating caterpillars in Illinois. However, because they may be found in a variety of outdoor and crop situations, persons finding slug caterpillars should handle them cautiously with tweezers or forceps. Anyone needing identifications of troublesome caterpillars may send or bring them in vials of alcohol to George L. Godfrey, Section of Faunistic Surveys and Insect Identification, Illinois Natural History Survey, 172 Natural Resources Building, Urbana, IL 61801.

A Leaf Miner in Soybeans

Many specimens of small dark red beetles were present in surveys of arthropods associated with soybeans made since 1969. These were determined to be *Odontota horni,* hispine beetles whose larvae formed blotch mines in leaves of native legumes such as *Amphicarpaea bracteata* var. *comosa, Desmodium illinoense, Tephrosia virginiana,* and *Meibomia rigida.* When soybean plants were searched, the blotch mines and larvae were found in the field.

Survey entomologist Marcos Kogan and his student assistant, Dan D. Kogan, studied and published on the life cycle and feeding habits of the adults and the larvae of this beetle in Illinois. The adults feed on the leaves leaving the veins intact, thus skeletonizing the leaf. The egg is inserted, usually singly, under the epidermis of the leaf usually on the lower surface. The larvae emerge after about six days and feed on the parenchyma near the egg forming a mine between the upper and lower surfaces of the leaf and feeding outwards from the position of the egg in all directions unless a major vein or leaf margin is encountered. The larvae when mature enter a pupal stage in the mine and the three larval and the pupal stage take about 25 days. Two generations per year probably occur in Illinois.

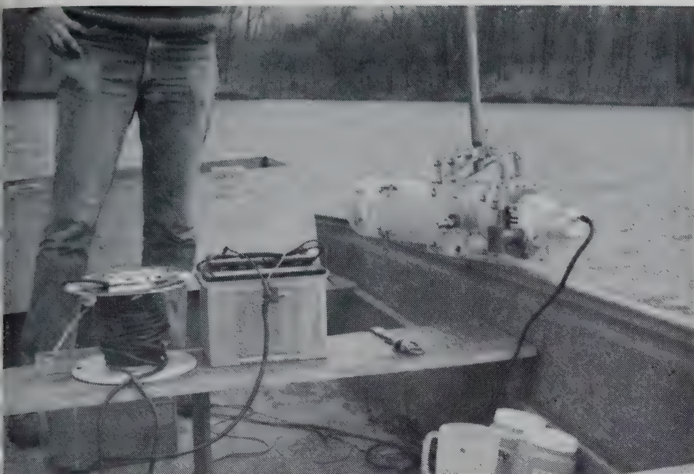
The potential of this species to cause economic damage to soybeans in Illinois is slight. However, the beetle may have to be taken into consideration if other more serious pests are also present and approaching the economic injury level.

From the viewpoint of the evolution of the arthropod fauna associated with soybeans in the New World, *O. horni* exemplifies a tendency also shown by the Mexican bean beetle and the bean leaf beetle. These are all oligophagous (feeding on few hosts) species with host ranges limited to a few genera of the plant family Leguminosae. *O. horni* seems to prefer *Amphicarpaea* and *Desmodium* as the natural hosts. Since *Amphicarpaea* is considered to be the closest New World relative to the soybean, the transition of this beetle would have been predictable. Documentation of a gradual adaptation of native legume fauna to the soybean as it i[s] introduced into new regions has both practical and theoretical aspects.

Submersible Vacuum Cleaner

Taking accurate and reliable samples o[f] aquatic microorganisms has been a his[-]torical stumbling block for many aquati[c] ecologists. Although many types of devices ranging from simple water bottles t[o] elaborate pump systems, have been de[-]signed and modified since the mid–1800's the recent demand for more stringent en[-]vironmental assessments and answers t[o] specific ecological problems has resulted i[n] the development of improved samplin[g] instruments.

Faced with the need for an apparatu[s] that samples zooplankton with repeatabl[e] precision from rivers and power plan[t] cooling lakes, as well as most other aquati[c] habitats, aquatic biologists Stephen W[.] Waite of the Natural History Survey an[d] Scott O'Grady of the University of Illino[is] developed a design that combines some o[f] the best features of two major types o[f] zooplankton samplers: the plankton ne[t] and the pump sampler. In most case[s] pump samplers have been proven superio[r] to other types of equipment for gener[al] use. They provide a reliable measure o[f] the water volume sampled and are pro[-]ficient in coves, shallow depths, and tu



Submersible vacuum pump collecting equipment with battery in boat (Photo by John Barlow, Aquatic Biologist).

ıulent waters. Nets, on the other hand, ırovide a convenient means of reducing he mass of organisms present in large olumes of water to smaller, more easily andled, concentrated samples.

Therefore, the priorities for a new apıaratus included the following objectives: o incorporate and enclose both a battery-perated pump and a high speed plankton ıet within a single submersible unit, readly obtainable materials in the sampler's onstruction, and to create a basic design hat can be readily modified for a variety f specific sampling requirements. The lesign of the new apparatus is relatively imple. It consists primarily of a pump ssembly, a filtering unit, a box-like strucıre that provides support for the whole pparatus, and a portable power supply battery) which is separate and remains vith the operator.

Prior to operation, the filter-pump apıaratus is lowered into the water and llowed to fill. The pump is activated with remote switch and the gear is raised and owered or held at a specific level in the vater depending on the sampling regime. t the end of the required time interval, he apparatus is raised out of the water vhere the netting is thoroughly rinsed. he sample is retrieved by removing a rass plankton bucket from the rear of ıe sampler and rinsing the organisms into bottle containing preservative.

Although the original apparatus was degned to sample zooplankton, its size and shape can be easily altered to collect other types of organisms including algae and stream macroinvertebrates. The uses of this sampler are many and vary according to the research needs.

Mercury and Lake Shelbyville

The analysis for mercury in largemouth bass and walleye collected from Lake Shelbyville in central Illinois in 1974 touched off an investigation of the lake's level of mercury contamination. Fish collected at that time had mercury concentrations substantially higher than those found in fish collected from other lakes in the same region of the state and several exceeded the 0.5 ppm Food and Drug Administration guideline. Reports of these results, with confirming analysis of the same samples by another laboratory and the collection and analysis of additional samples, caused the Illinois Department of Conservation to issue a warning to fishermen about consuming excessive amounts of these fish. During the next two years, fish from Lake Shelbyville continued to show similarly high mercury concentrations and the warnings were reissued annually.

In 1977, a two year investigation of the lake was begun by Survey analytical chemist Kenneth E. Smith and his associate Aaron P. Griffith under joint funding from the Illinois Natural History Survey and the Illinois Institute of Natural Resources. The study was to determine if a point

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source, or sources, could be found for the mercury contamination and to determine the bioaccumulation occurring in the lake's aquatic ecosystem.

Seventeen sampling sites were established to cover major tributary streams as well as central areas in each of the three arms of the lake. Water samples were collected monthly from each station, as well as samples of bottom sediment, clams (when present), zooplankton, and five species of fish. For the tributary stations, samples of terrestrial soil were collected 2-3 kilometers upstream from each tributary's mouth. All samples were analyzed for total mercury and results were interpreted with the aid of statistical tests.

The results indicated that there was not a distinguishable point source, or area, which was contributing the mercury contamination to Lake Shelbyville. Results of the analysis of the biota collected from the lake also were not indicative of a contamination in one area of the lake.

The bioaccumulation of mercury in the lake's food chain was determined from the results of the analysis. Beginning with water as a background value, and continuing through the plankton, clams, and lower trophic level fishes to the major predators, a steady accumulation was found. Normalizing the mean mercury concentration of the plankton as 1 an expressing the concentrations of the othe biological organisms as multiples of th factor yield the following bioamplificatio scheme: plankton (1), clams (2), gizzar shad (7), bluegill (10), carp (21), large mouth bass (20), and walleye (30).

Since 1974, a highly significant corre lation has existed for the predator specie between their size and the concentration c mercury in their tissues. In 1974 this re gression predicted that bass over 0.5 k would exceed the FDA 0.5 ppm guidelin while the regression for the bass collecte in 1978 predicted this size to be 2.2 kg a the same level of confidence (99% level The same trend was seen for walleyes, be ginning at 2.0 kg for the 1975 collectic and rising to 3.1 kg for the 1978 colle tion. This indicates that the level of con tamination is decreasing and soon may r longer be a problem for the fishermen.

A postulated mechanism for the me cury's entrance into the aquatic ecosyste involves methylation of mercury absorbe on soil once the soil is flooded and ente an anaerobic system. As mercury in tl now lake-bottom soil is depleted, less me cury would be available to the biota the lake and once methylated, vario pathways would be available for remov of mercury from the aquatic environmen

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SURVEY REPORTS

NOVEMBER 1979, NO. 191

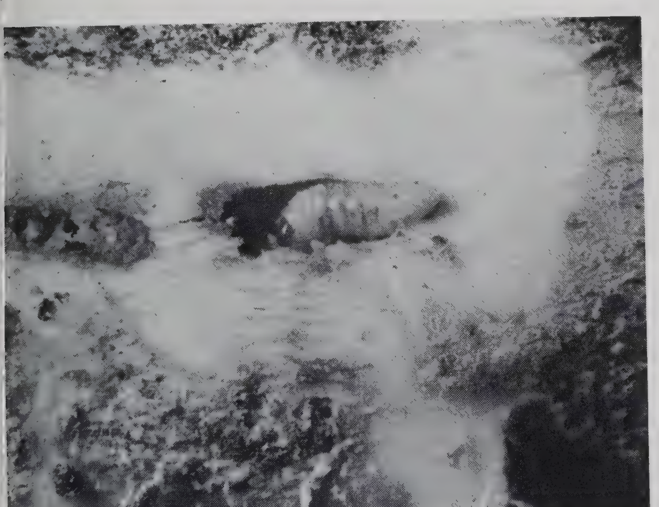
Control of the Imported Crucifer Weevil in Horseradish Planting Stocks

In 1977 the imported crucifer weevil, *Baris lepidii* Germar, was discovered infesting fields of horseradish in St. Clair and Madison counties. Previously, this insect had been considered an occasional pest of crucifers only in central Europe and the USSR. The adults feed on stems and roots and lay eggs in tissues of primary and secondary roots. The white, grublike larva is the most damaging stage because it tunnels in the roots.

Horseradish is produced for its fleshy, pungent roots. The method of growing horseradish greatly influences the spread and establishment of this weevil. Horseradish is vegetatively propagated by planting 30- to 35-cm pieces of pencil-thin secondary roots ("sets") in early spring. The crop is harvested in late fall and in the succeeding spring. Primary roots are sold for processing, and sets are stored in underground soil pits or in cool cellars to be used for planting in the spring. Many root pieces remain in the soil following the harvest, producing extensive patches of horseradish in rotation crops in the succeeding year. Horseradish is usually rotated with other crops and is planted on the same land every other year.

The imported crucifer weevil overwinters in Illinois as adults, eggs, and larvae in unharvested or volunteer horseradish and as eggs and larvae in stored sets. Infestation of the commercial horseradish crop occurs through the dispersal of weevil adults from infested volunteer horseradish and through the planting of sets containing eggs and larvae.

Illinois Natural History Survey economic entomologists R. E. Foster, Dan Sherrod, Cathy Eastman, and Roscoe Randell investigated procedures for reducing field



An imported crucifer weevil, *Baris lepidii*, larva in a typical feeding channel in a horseradish root.

infestations of the imported crucifer weevil by the destruction of eggs and larvae in horseradish sets. They evaluated techniques using hot water dips, fumigants, and insecticide dips.

The entomologists sum up their findings in this way. Dichlorvos as a dip or a fumigant proved ineffective at killing eggs of the imported crucifer weevil. Hot water treatments showed promise but should be abandoned because of the difficulty of maintaining precise water temperatures for large commercial crates of sets. Fumigation with methyl bromide also appeared promising but would require further research to make it usable by growers.

Immersing the sets in permethrin was the most useful method tested. While this treatment had little effect on larval survival, egg mortality was high. Eggs were by far the most numerous stage present in sets, and a recent examination of sets showed that few larvae survived the winter. Set sprouting was not affected by treatment with permethrin at concentrations of 0.1 to 0.5 percent for exposure times of 30, 60, and 120 minutes, and by the end of the growing season only minimal permethrin residues persisted in the roots.

Breaker, Breaker. Come in, Good Bassy!

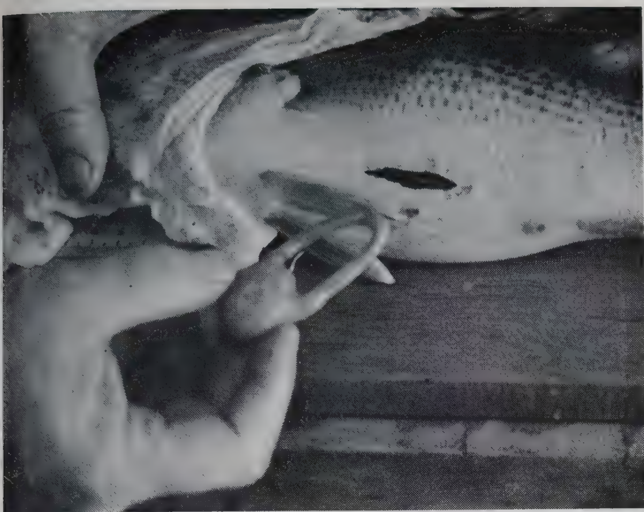
For more than 20 years Survey biologists have been tracking all sorts of animals from hawks to squirrels and, more recently, fish. The imagination and engineering skill of William Cochran, wildlife specialist, in developing tiny radios that can be attached to these animals have permitted following them in the air, on the land, and in the water. In 1970, working with fishery biologist Weldon Larimore, Cochran designed a radio that could be surgically implanted in the body cavity of a fish. The small radio with its battery and loop antenna resembles a small padlock about 1½ inches long.

The Survey's first extensive fish radiotracking program was in Lake Sangchris, a power-plant cooling lake in central Illinois. The biologists were interested in how largemouth bass moved from day to day through the seasons and how they re sponded to the warm water being di charged into the lake by the power plan About the same time a companion stud was being conducted at Lake Shelbyvill a main-stream impoundment where wate levels fluctuate throughout the year. Ho bass responded to changes in water leve was the primary objective of that study.

Recently a new and more sophisticate radiotelemetry study has been initiated i the Salt Fork River of east-central Illinois where Dr. Larimore is following the move ments of smallmouth bass. Although thes small radios developed by the Natura History Survey have been used in cold water rivers of the West to follow the ex tensive movements of salmon and trout, n such work has been done in our mor turbid, warmwater streams, and nearly al Illinois streams are of this type. The spe cific area of the Salt Fork being studied i a 15-mile stretch southwest of Oakwoo in Vermilion County. When a smallmout bass has been selected for the experimen and the small radio has been surgicall implanted in the body cavity, it is given a numbered 2-inch long piece of yellow plastic tubing that is attached to the fish's back. On this tubing are the fish's numbe and a telephone number that can be used if the fish is caught by an angler.

Each radio put in a fish is on a different frequency so that the fish can be identified when a biologist picks up a transmitted signal. The actual tracking of the fish, a search for each fish with its distinctive signal, is done through two systems. In one system the biologist simply moves up and down the river "listening" for the radio signal to show the exact location of an experimental fish. The other system is more complicated; it includes a tall fixed receiving antenna that can pick up signals over a mile or so of stream. The signal is then recorded automatically on a chart.

What is this research all about? Dr. Larimore is trying to associate the daily activities and seasonal movements of our sport fishes with their breeding and feeding requirements, and to understand their responses to changes in water conditions,



Miniature radio transmitter about to be implanted in the body cavity of an anesthetized bass.

such as increased turbidity and water levels during flood periods or drastic drops in water flow during droughts. He will be able to observe the responses of fish to changes in water quality, such as pollution, that might cause the displacement of river fishes.

There are many interesting and exciting potentials for this work, and Dr. Larimore is anxious to have the help of fishermen that fish this river. Their cooperation can add tremendously to the research results. It is hoped that these special fish will be released after the fisherman has noted the tag number and the telephone number. A call to the fishery laboratory would then provide valuable information and save the experimental fish. If, however, the fish is accidentally killed by hooking or dies before the tag is noticed, the angler is encouraged to save the tag from the back and the radio from inside the fish and then report his catch. Because the cooperation of fishermen is so important to this study, they are encouraged to call the Survey at (217) 333-6890 to ask questions or further discuss the work. As this research progresses biologists may be able to tell fishermen where to look for bass during different times of the year and under different conditions. Certainly the biologists should learn more about the habitat requirements of our river fishes and ultimately be able to protect and improve habitats in our Illinois rivers.

Measuring Migrant Bird Populations

The large numbers of transient birds that pass through Illinois each year probably have an important influence on the habitats they use, yet absolute measurements of these populations are virtually nonexistent. Students of bird populations have concentrated on studies of breeding and, to a lesser extent, winter populations. There are at least two reasons for this choice of seasons: (1) the obvious importance of the breeding cycle (i.e., productivity) and winter survival on the ecology of species, and (2) the fact that nesting and winter populations, once established, are relatively stable from day to day. By contrast, the ephemeral nature of the transient populations has made censusing seem impracticable.

The transect census technique developed by the Illinois Natural History Survey's early investigators, Stephen A. Forbes and Alfred O. Gross, is potentially a useful method of measuring transient bird populations. In April and May 1979, ornithologists Richard and Jean Graber applied the technique to measure populations of birds in arboreal habitats in southern and central Illinois. The investigators were concerned that the numbers of transients present on some days would overwhelm their capability to detect and record. Daily censuses in April and May proved the method workable for even the highest

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populations encountered, and the census will be continued through the fall and next year.

The pressure which the transient populations exert on a habitat can be seen in a comparison of the density of the population in April and May with that of the June breeding population. For example, in a bottomland forest tract with a breeding population of 40 bird species and a density of 266 birds per 40.5 hectares (100 acres), the average daily population of transients was composed of 58 species at a density of 571 birds per 40.5 hectares, i.e., more than twice the breeding population. The pressure of these populations on the habitat might be more realistically expressed in terms of biomass or the metabolic requirements of the animals involved. In either case the comparative pressure of the transients might be somewhat lower than the densities suggest because many of the species (e.g., warblers) are small.

It is also necessary to note that the breeding densities referred to above do not include young that are produced on the area, a component which would definitely swell the importance of the breeding population (to an unknown, but calculable, level).

With just the data from the spring censuses, it is already clear that transient bird populations are of great importance to Illinois habitats, and vice-versa. An important practical question that needs consideration is whether, and to what extent, the transients affect the resources of the breeding bird populations.

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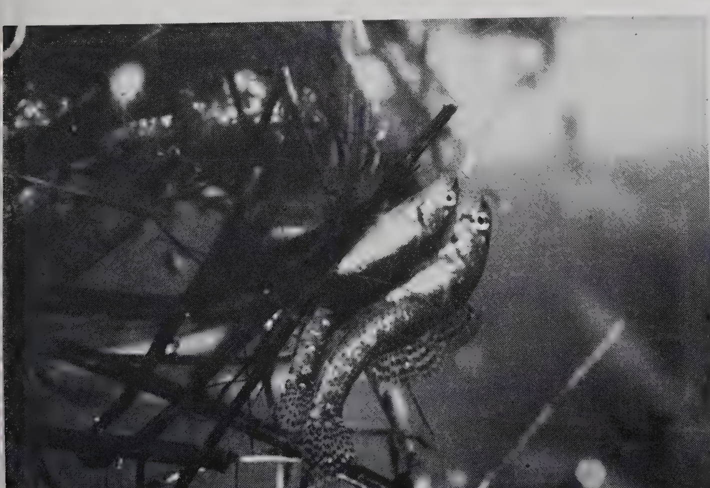
DECEMBER 1979, NO. 192

east Darter Biology

At the turn of the century, 26 species of arters occurred in the streams and lakes Illinois; however, only 23 are known to emain. Of these 23, ten have been the ıbjects of life-history studies conducted by resent and past Survey personnel over the ıst 12 years. The latest study to be comleted and published by former Survey :hthyologist B. M. Burr and Survey ichıyologist L. M. Page concerns a tiny speies called the least darter, *Etheostoma ıicroperca*. The least darter has a modertely large range in eastern North America nd reaches its greatest abundance in the Great Lakes region. The population chosen or study was in a small, unnamed tribuary of the Iroquois River near Watseka n Iroquois County, Illinois. The tributary vas a narrow, shallow creek with grassovered banks and, during the summer nonths, thick growths of filamentous algae.

One year of field and laboratory work revealed that the least darter has a life history similar to that of the closely related cypress darter. In Illinois the least darter reaches a maximum length of 32 mm and lives a maximum of only 20 months. Like the cypress darter, the least darter has a deeply indented egg, an unusual feature among freshwater fishes which generally have spherical eggs. At one year of age and mostly during the month of May, the least darter spawns in filamentous algae close to the edges of the stream. The male mounts the back of the female, grasps her with his large cuplike pelvic fins, and then the two ascend to the site of egg deposition. The spawning pair usually assumes a vertical position and one to three eggs are laid at a time. Eggs are left unattended and, at 20°C, hatch in about 7.5 days. Growth is rapid for the first six or seven weeks. By October, the population reaches its peak density with as many as 33 darters per



Least darters spawning (Photo by Brooks Burr, Southern Illinois University at Carbondale).

square meter of stream bottom. The diet consists principally of larval midge flies and small crustaceans.

Public awareness of the importance of nongame fishes in the overall maintenance of diversity and stability of aquatic ecosystems has made the INHS life-history studies all the more valuable. In fact, the Survey has become established as one of the centers for the study of fish life histories. Future proper management and protection of Illinois' nongame fishes will depend in large part on the rational use of baseline data presented in such life-history studies. Copies of the publication on the least darter, *Biological Notes* No. 112, are available upon request to the Survey.

Wood Duck Populations

The wood duck population on the Quiver Creek study area rebounded in 1979 after a serious decline in 1978, according to Survey wildlifer Frank Bellrose. There were 113 nests in 1979 compared with 86 in 1978, and nest success in 1979 was 63.7 percent compared with 31.1 percent in 1978. In 1978 only 39 percent (15) of the incubating hens were new ducks, but despite the poor hatch in 1978, 46 percent (34) of the incubating hens were new in 1979.

In most instances new hens are yearlings hatched on the area the previous year. Yet there are these incongruities: in 1977, there was a 78 percent hatch of 166 nests, but only 15 new hens turned up in 1978. Of 1,013 ducklings marked in 1977, none was found in 1978 or in 1979. To further cloud an understanding of what occurred, 22 incubating hens banded on the nest in 1976 and 1977 appeared in 1979 after failing to put in an appearance in 1978.

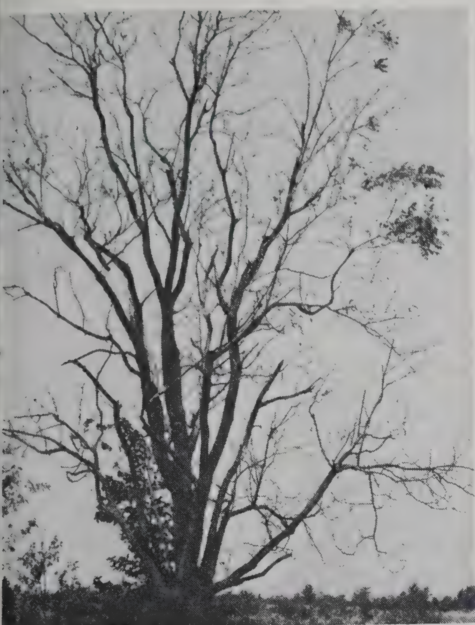
It appears that a high loss of young occurred in 1977 that almost eliminated the return of yearlings. This loss was further compounded by the unprecedented nesting by older hens off the study area in 1978. A study of previous records indicates that in the past 26 years an average of four hens per year nested outside the study area or were not found if they nested on the study area.

Is there a relationship between the hens that were not found nesting in 1978 and the disappearance of hatched young during the summer of 1977? That summer, 67 sick wood ducks were noted on the study area, by far the largest number of ill ducks ever noticed. Did their behavior alarm other ducks, causing them to nest elsewhere in 1978 but return in 1979?

Average survival of nesting wood duck hens over a period of 20 years is 49 percent. Between 1976 and 1977 it was 66 percent, between 1977 and 1978 it was 30 percent, and between 1978 and 1979, it was 50 percent. Clearly an unusual mortality unrelated to hunting decimated the Quiver Creek wood duck breeding population between the 1977 and 1978 nesting seasons.

Walnut Caterpillars and Wood

Black walnut is the most important timber and nut tree species grown in Illinois. Because of the increased demand for walnut lumber, there has been a drastic reduction in the natural stands of this tree. In recent years an increased interest in planting walnut trees has occurred. Insects can often cause problems in such plantings. Of the insects which feed on walnut foliage, the walnut caterpillar is the most serious. When the walnut caterpillars are abundant, complete defoliation of trees often occurs, thereby weakening the trees and making them more susceptible to insect borers which destroy the quality of the wood and can result in the death of the trees. Through a research project funded by the USDA Forest Service and The Joyce Foundation, Survey entomologists, Marion Farris and James Appleby, conducted studies on the life history of the walnut caterpillar. They found that the female moth always deposits its eggs in clusters on the lower leaf surface. Tiny wasps often parasitize such egg masses and during certain years may account for 26 percent of the eggs not hatching. After the eggs hatch the walnut caterpillar larvae are often attacked by predaceous stink bugs and wheel bugs. Certain flies and wasps will sometimes lay their eggs on the

On the left is a mature walnut tree defoliated by the walnut caterpillar (Photo by M. E. Farris). On the right is a group of walnut caterpillars on foliage of walnut tree (Photo by J. E. Appleby).

caterpillar or insert their eggs within the caterpillar's body. The parasitic larva develops within the caterpillar's body, eventually resulting in its death. The adult fly or wasp will emerge the following year and search out other walnut caterpillars to parasitize. The walnut caterpillar is generally controlled by its natural enemies; however, periodically the insect's natural controls are ineffective and populations of the walnut caterpillar become epidemic. To prevent such outbreaks growers may have to resort to using insecticide sprays for control. Experiments were conducted at the Dixon Springs Agricultural Center in southern Illinois to find insecticides that would be effective but would not have adverse environmental effects. Farris and Appleby found that insecticides such as acephate (Orthene), *Bacillus thuringiensis* (Dipel), diazinon, and malathion were effective in controlling the caterpillars. Through such studies the walnut grower will now have a better understanding of the walnut caterpillar so that the walnut seedlings of today will eventually grow to maturity and become walnut furniture of the future.

Redear Sunfish in Illinois

Redear sunfish, *Lepomis microlophus*, originally were inhabitants of the southeastern states. They were introduced into Illinois in 1946 to supplement the state's sport fishery. Reservoirs and ponds throughout the state were stocked with this species, but the deep, warm-water lakes provided the most suitable habitat for the redear. Stocking resulted in self-sustaining populations in most of these lakes, and the fast-growing redear became an established sport fish.

The redear populations in some Illinois lakes have recently declined, and in other lakes have totally disappeared. The cause for these changes, whether inherent to the species or its habitat, is not apparent.

Survey aquatic biologists Dee A. McCormick and Warren U. Brigham conducted an extensive literature review of published and unpublished works on the life history of the redear sunfish with Dingell-Johnson funds through the Illinois Department of Conservation. The primary objective of the study was to determine which factors limited redear sunfish in Illinois waters. The report concluded that these fish are limited in Illinois primarily

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by temperature and competition. Temperature may limit the species by substantially reducing its reproductive success in northern waters. The shorter spawning season in Illinois commonly limits redear to one spawn per year. Redear may spawn throughout the entire summer in southern portions of its range. In addition, juvenile redear may not be able to endure the low temperatures common to northern and central Illinois winters in shallow lakes.

Competition for food and space may limit the species in habitats which are less than optimal for redear success. The lakes and ponds of Illinois which contain stocked redear populations commonly are more turbid than those in which redear naturally occur. The low light penetration in turbid water limits the depths to which aquatic plants grow and may force th redear into weedy shallow water wher they must compete with other sunfish fo food and space.

The effects of temperature and compe tition on redear have not been studied i detail. Survey aquatic biologists are pro posing a comprehensive field study to de termine the nature and degree to whicl temperature and competition limit redea sunfish populations in the lakes of Illinois Upon completion of this investigation i will be possible to formulate an effectiv management plan for the redear sunfish i Illinois. Such a plan will make it possibl to restrict the stocking of redear sunfish t those lakes providing favorable condition for the species and to enhance its status a a sport fish.

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NATURAL HISTORY SURVEY REPORTS

JANUARY 1980, NO. 193

\ Treatment for "Anemic" Trees

Yellow foliage (chlorosis), sometimes aused by iron deficiency, and slow growth re typical of many trees planted along treets and around homes where the origi- ial topsoil has been removed or mixed vith the subsoil. The average urban soil ias relatively poor physical, chemical, and iological characteristics. Tree root de- relopment and penetration are greatly educed in heavy clay subsoils that lack idequate aeration and water drainage. Ad- litionally, the amount of available nutrients ind organic matter is often critically low. Agronomically, urban soils are usually a onglomerate of rubble.

Trees growing under urban conditions requently exhibit nutrient deficiency symp- oms. When these symptoms occur, they ire often difficult to diagnose. However, plant pathologist Gene Himelick has found hat correcting the deficiency is inexpen- sive and may be effective for 2, 3, or even 4 years. If affected trees remain untreated they usually continue to decline, but sys- temic treatment for chlorosis will prolong he life, improve the vigor, and increase the aesthetic value of a tree.

Most urban trees manage to survive for at least a few years despite poor soil con- ditions and other environmental stresses. In Illinois, chlorosis is a common problem of pin, red, and white oak; bald cypress; sweet gum; river birch; silver and red maple; and hackberry. Occasionally it oc- curs on American sycamore.

In tests begun in 1974, Himelick and his associates tested ferric citrate powder and commercially prepared capsules (Med- icaps) containing ferric ammonium citrate; highly soluble nitrogen (N), phosphorus (P), and potassium (K); and a slow-re- lease nitrogen source as possible corrective treatments for chlorosis. Six tree species were used in the tests: pin oak, bald cy- press, red oak, swamp white oak, sweet gum, and American sycamore. The trees were located on the Urbana campus of the University of Illinois and were 6–40 inches in diameter at breast height (dbh).

A plastic syringe was used to inject the ferric citrate powder into small holes drilled 4 inches apart around each tree trunk. The commercially prepared gelatin capsules were enclosed in slotted plastic coverings and were driven into holes drilled about 6 inches apart around the trunks of trees to be treated.

The ferric citrate treatments were ef- fective on pin oak, cypress, red oak, swamp white oak, and sweet gum. Only slight re- sponse was obtained on American syca- more.

In 1977 the test was expanded to in- clude pin oaks and sweet gums growing on parkways in Urbana.

In this test, pin oak responded well to all treatments with iron compounds and to combinations of iron and nutrients. The sweet gum response to all treatments was generally not as definite as those obtained on pin oak. Trees treated with ferric ci- trate responded best and, in general, the distribution of the compound appeared better than in other treatments. The com- bination of ferric ammonium citrate and soluble NPK gave slightly better color re- sponse in pin oak than did the use of the iron compound alone. Some response was

A pin oak showing a[illegible] vanced symptoms of chlor[illegible] sis, or yellowing of th[illegible] foliage. Systemic treatme[illegible] with iron compounds ge[illegible] erally corrects the iron d[illegible] ficiency.

achieved through the use of soluble NPK in both pin oak and sweet gum, but the use of slow-release N alone gave no measurable response.

White oaks that had been chlorotic 2–6 years growing on parkways along streets in Highland Park were treated to determine if they would respond to either iron or manganese. The trees (average dbh, 20.8 inches) were treated between May 4 and 8, 1978. Color ratings were made on June 7 and August 1, 1978, and August 23, 1979.

The color response at the end of the first and second growing seasons was relatively poor. There appeared to be no difference in color response between the use of iron and of manganese.

The use of ferric citrate as a powder or ferric ammonium citrate as Medicap[illegible] provides a reasonably effective and eco[illegible] nomical way of treating large chloroti[illegible] trees. The results of treatment have bee[illegible] more pronounced in trees showing ad[illegible] vanced stages of chlorosis than in thos[illegible] exhibiting early stages. However, it is ad[illegible] visable to begin treating chlorotic trees be[illegible] fore they have advanced to the later stage[illegible] of chlorosis and decline.

Proper timing of the treatment is im[illegible] portant in correcting chlorosis. Treatment[illegible] completed in late summer generally wer[illegible] not effective until the following year, an[illegible] the treatment lasted only 1–2 years. Late[illegible] dormant or April and May treatment[illegible] have been found to be most effective, an[illegible] the treatments last for 3–4 years.

For specific information on how to trea[illegible]

chlorotic trees, contact the Botany and Plant Pathology Section of the Illinois Natural History Survey.

Testing the Toxicity of Ammonia to Illinois Fishes

Under the Clean Water Act, a national goal is the attainment of fishable, swimmable waters, wherever possible, by 1983. To achieve this goal, water quality standards must be set which will limit pollutant concentrations to levels that will protect aquatic life. On the other hand, complying with the standards in the treatment of wastewaters discharged into streams may be costly. Thus, the standards should not be more stringent than is necessary to protect aquatic life.

Most studies on effects of pollutants on fishes have been done with a few species, especially trout, and for exposure times of only 2–4 days. There is a scarcity of information on the water quality requirements of most Illinois fishes, particularly for exposure times of more than 4 days.

Recently aquatic biologists Keturah Reinbold and Richard Sparks, with their associate, Stephen Pescitelli, began a study of the toxicity of ammonia to Illinois fishes with funding from the U.S. Environ-

Aquatic biologist Keturah Reinbold makes an adjustment on the flow-through system being used to test the toxicity of ammonia to Illinois fishes.

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mental Protection Agency. Ammonia is an important pollutant in Illinois from sewage effluents, feedlot runoff, and urban runoff.

The ammonia toxicity tests are being conducted in a continuous-flow system. Several concentrations of the pollutant are tested simultaneously in a series of test chambers, each of which receives a constant concentration in a continuous flow of water. This is a better method for toxicity testing than has often been used in previous studies in Illinois. Previously the test material and animals have been placed in static water. The flow-through system more closely resembles conditions in a natural stream. Also a constant concentration of the test material is maintained even for volatile substances such as ammonia, which move out of standing water into the air, and for unstable compound that break down in standing water.

In the Survey study fishes are teste during their early life stages. Since thes are usually the most sensitive parts of th fish life cycle, the results are more indica tive of the tolerance of the species thar are tests with adults, which have mos often been done in the past. Four fis species will be tested: green sunfish, whit sucker, channel catfish, and walleye. Th tests begin with fertilized eggs and con tinue for 4 weeks after hatching. Effects o egg survival and hatchability as well a on growth and survival of young fishe will be evaluated. The current water qual ity standards for ammonia are being re vised in Illinois and in the Midwest region and information from this study will b used in the revision of the standards.

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NATURAL HISTORY SURVEY REPORTS

FEBRUARY 1980, NO. 194

Red-headed Woodpeckers and Acorns

One of the most characteristic sounds of the bottomland forests in winter is the raspy bickering of red-headed woodpeckers defending their food caches. The woodpeckers seemingly chase everything that approaches, from innocuous-looking brown creepers and titmice to squirrels, and from each other. The spectacle of irritated birds flying at one another through the tree tops may be somewhat comical, but it is actually a serious matter of survival. When one sees how hard the birds work to acquire their food stores, the reluctance to share is understandable. A particularly striking example of such work was observed in mid-October 1978 by Jean and Richard Graber in the course of field work in bottomland forest along the Kaskaskia River west of Vernon, Illinois. Several red-heads were collecting and storing acorns from a cluster of three mature pin oaks (*Quercus palustris*) standing about 100 meters from a large block of forest.

Each bird, acting independently, landed in the upper third of a mast tree, picked an acorn, and flew to a storage site in the forest. As many as 12 red-heads could be seen in the air at once. Most were adults, but two were obviously immatures, and the immatures were gleaning acorns exactly as the adults did.

One immature red-head whose entire route could be observed took 41 seconds per round trip from his storage tree, a dead cottonwood (*Populus deltoides*) some 135 meters from the mast trees. Other red-heads had more distant storage sites, but none required more than about 90 seconds to complete a trip. Each bird had its own storage tree. There was no strife between birds at the mast tree, but noisy conflicts occurred whenever any bird came near another's storage site. Apparently acorns at the harvest site are common property, but once gathered they become private property.

From the time required per trip, it was calculated that the 20-25 birds observed were storing 800-1000 acorns per hour. Such intense activity lasted only a few days from the time the acorns became mature until they fell. Ten days later the mast had

Fig. 1. Red-headed woodpecker at nest entrance (Photo by wildlife biologist Dick Graber).

fallen and the birds were no longer visiting the mast trees. From counts made of acorns under the trees and estimates of canopy area, the mast crop that year was about 500,000 acorns per hectare in that site, a very good crop. Jean and Dick Graber reported this incident in a paper in the *Illinois Audubon Bulletin* in the spring of 1979.

Winter red-headed woodpecker populations in southern Illinois show a strong correlation with the importance of the pin oak in forests and with oaks of acorn-bearing size (Graber et al., 1977, INHS Biological Notes No. 102). Moreover there are annual regional fluctuations in numbers of winter red-headed woodpeckers which are probably based to a large extent on the mast crop in the winter range, the center of which for the red-head lies in southern Illinois. The population of winter red-heads in southern Illinois tends to show an alternate-year pattern of highs and lows, and acorn production varies greatly from year to year. This poses an interesting question concerning homing, i.e., the return by an individual bird to the same wintering territory every year. Homing is well developed in birds, but must be very different in a temperate-zone mast feeder such as the red-head. Why home to an uncertain food supply? We will never understand fluctuations in Illinois bird populations until we have consistent, precise annual measurements of their food resources over wide areas. Such understanding is vital to insure that sufficient areas with suitable food plants are provided in order to preserve our wildlife heritage.

Havana Lab Welcomes Electronic Assistant

First, the good news: the Illinois River has been called the most studied river in the world. Illinois Natural History Survey data on its flora and fauna date back to the 1890's. Then, the bad news: a conscientious researcher often has to work full-time for weeks or months just to pick out and tabulate any one aspect of this vast store of biological information. Imagine trying to decipher hundreds of 4(year-old note cards on which the length and weights of fish were hastily jotte down.

Now, the *really* good news: the Aquat Biology Section at the Survey's River R search Laboratory near Havana is using new Tektronix 4051 intelligent graphi terminal, plotter, and hard-copy unit t organize its river data for a variety of r search needs. Aquatic biologist Ken Lubir ski is currently teaching the staff how t use the computer to help investigate th river system.

Want to know how many spottail shiner Survey biologists minnow seined from th Illinois between 1957 and 1978? Until re cently, you would have had to dig ou files for each of the fourteen availabl years, check for spottail shiner in up t 260 lists of fish for every year (four haul at each of as many as sixty-five stations) write the numbers down on another shee of paper, add them up for each year, and divide by the number of hauls. Even a fast worker with a calculator would probably make some mistakes during this tedious procedure — which could eat up four weeks working time.

Havana Lab staff members can now pull the same information out of the computer in five minutes or less — leaving them nineteen days, seven hours, and fifty-five minutes for analysis or field work. All one needs do is put the right tape in the terminal and type in genus and species and the years desired. Buzzing and beeping, the terminal quickly lists the years, reaches of the river, and numbers of spottail shiners taken in each. You can have the list turned into a histogram display, printed on paper by the attached hard-copy unit, or stored for computer plotting as a graph of publishable quality. If you are curious instead about a particular year or area of the river, you can have the data reorganized into a different listing.

Once workers complete the initial labor of correctly punching in the data, the information remains handy for all kinds of uses. Minnow seining, electrofishing, and water quality files for the Illinois River are already accessible.

Fig. 2. *Andrena carlini* on flower of toothwort. This is one of the most important native blueberry pollinators (Photo by Joseph Laury Luth).

Rapid tabulation is only the first step. Yip Tai-sang, survey computer programmer, has written several programs to analyze, sort and display these files. The computer will also make it easier to analyze relationships between two sets of data, such as fish distribution vs. pollutant concentrations or habitat conditions. Of course, the size of the computer's memory limits the volume of data it can process — but a telephone coupler sidesteps this limitation by allowing the Havana terminal to communicate with larger computers when necessary and borrow their larger memory capacities.

This technological revolution could not have come at a better time. As biologists struggle to keep abreast of both voluminous paperwork and fast-changing natural systems, the computer's help in reducing errors and saving time and labor is especially welcome.

Blueberries and Bees

Blueberries are dependent upon native bees for pollination. Without this service, blueberry crops would be nonexistent or inadequate. Honeybees are not good pollinators of blueberries because these plants bloom at a time of year when honeybee colonies are inactive or small and most blueberry crops are grown in northern areas where keeping of honeybees is a marginal enterprise.

The Canadian province of Nova Scotia produces large crops of blueberries. Recent failures of this crop has been attributed to the aerial spraying of insecticides to control spruce budworms and the insecticide (Fenitrothion) used was highly poisonous to native bees. Dr. Peter Kevin, now located at the University of Colorado in Colorado Springs, in cooperation with Survey entomologist W. E. LaBerge has studied the diversity of bees in blueberry fields in Nova Scotia. They have been able to show a decrease in diversity correlated with the use of Fenitrothion and correlated with decreased blueberry yields.

During the six years since Fenitrothion was discontinued in spruce budworm control the diversity of the bee fauna has been carefully monitored. This diversity has been increasing and has about reached the level it was before Fenitrothion was used. Blueberry crop yields have concomitantly increased to normal levels. A report of this project was made to the Sixth International Symposium on Pollination held at the University of Maryland in 1978 and was published in the *Proceedings* of that symposium.

This work is an example of what can be learned with the cooperation of rather distinct disciplines in biology, in this case

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an ecologist and a taxonomist. The thousands of specimens from the study are deposited in the collections of the Survey.

Custom Spray Operators School

The Thirty-Second Custom Spray Operators Training School was held January 8-10, 1980 at the University of Illinois. Opening the three day program were technical meetings of the Illinois Ground Sprayers Association and Aerial Applicators Association. These meetings were held at the Ramada Inn Convention Center in Champaign. Moving to the Illini Union on Wednesday and Thursday, the formal program included speakers from the U of I, Illinois Natural History Survey, and several invited speakers from across the U.S. Attendance at the 1980 School was 1,579.

The goal of the Spray School is to kee custom pesticide applicators and pesticid dealers aware of new developments in a phases of agricultural pesticide use. I addition, a special section of the forma program this year was on scouting tech niques for insects, weeds, and plant disease Delivering the keynote address was Mı Steven Jellinek, Assistant Administrator o the federal EPA. His topic was on th future direction of federal pesticide regu latory programs.

The Custom Spray Operators School presented by the Cooperative Extensio Service of the University of Illinois an the Illinois Natural History Survey, is con sidered by many to be the finest school o its type in the nation. During its 32 yea history it has kept Illinois agricultural pes ticide applicators alert to changing tech nology and pest management practices.

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ATURAL HISTORY

SURVEY REPORTS

MARCH 19[illegible] NO. [illegible]

inding Insect Enemies ' the Alfalfa Weevil

The alfalfa weevil, *Hypera postica* (Gyl-nhal), and the clover root curculio, *itona hispidula* (Fabricius), are the most amaging insect pests of alfalfa in the Jnited States. The alfalfa weevil is capa-le of defoliating an untreated alfalfa eld, while the clover root curculio feeds n root nodules, lateral roots, and tap oots. Economic entomologists R. J. Barney, . J. Roberts, R. D. Pausch, and E. J. rmbrust undertook this study to find spe-ific predators of these two weevil pests nd to measure their relative abundance nd activity in the alfalfa field.

Pitfall traps were fashioned from gal-vanized metal guttering cut into 1-meter ong sections, and caps were attached at oth ends. Clear bathtub caulk was used to eal the traps and prevent leaking.

The linear traps were aligned parallel to a woods bordering the alfalfa field. The traps were sunk into the soil in a staggered pattern of six rows with seven traps in each row. The rows were so aligned that no trap overlapped another trap as they faced the woods. In this manner any mass movement of predators into or out of the woods could be detected.

The 42 pitfalls were partially filled with ethylene glycol to catch and preserve any insect falling into the trap. Every week from 12 September to 15 November the traps were emptied of all insects.

The carabid beetles, *Harpalus pennsylvanicus* DeGeer, *Abacidus permundus* (Say), and *Evarthrus sodalis* LeConte, and a cricket, *Gryllus pennsylvanicus* Burmeister, were the most abundant potential predators found over the 2-month period in the linear pitfall traps. These four species accounted for 94.5 percent of the potential predators caught. Other researchers had found that the most commonly caught carabids are probably the most active and numerous and have the greatest potential for finding and destroying prey that occur on the ground. This 2-month period is also the time of migration by weevils from aestivation sites in the woods back into alfalfa fields. Therefore the weevils are concentrated and susceptible to predation during this field reentry process. The three carabids and the cricket species were also the most frequently caught in conventional pitfall traps in alfalfa in an earlier investigation by economic entomologists R. Cherry and E. J. Armbrust. Cherry and Armbrust recorded the highest catches of predators in September and October, which corresponds to the timing of this study, with the trapping slowing down in November as cold temperatures restricted insect activity.

Live potential predators were collected in a dry pitfall trap. The insects were individually placed in ½-pint cartons containing some litter and covered with organdy. Each of the potential predators was supplied with two weevils, which were replaced when and if eaten. Each individual predator was supplied with only one species of weevil before it was discarded. Five repetitions of each predator with each weevil species were run for 1 week.

All four potential predators tested preyed on both the weevil species. The beetle,

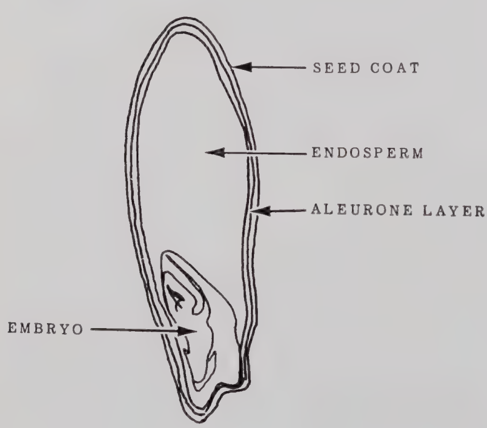
H. pennsylvanicus, and the cricket, *G. pennsylvanicus,* were the most voracious eaters, consuming almost twice as many weevils as the other two.

Cherry and Armbrust found the same four species to be predacious on cocoons of *Bathyplectes curculionis* (Thomson), the primary endoparasite of the alfalfa weevil. Therefore, the four predators many exert more pressure on the beneficial parasite than on the pest. The fact that these general predators feed on both pests and beneficial insects of the alfalfa agroecosystem makes it very difficult to determine their impact on the pest population.

Cellular Control of Seed Dormancy and Germination

A dried-out seed is a "dormant" (literally sleeping) seed. If the dormant seed falls to the ground, it takes up water and resumes its interrupted growth; this process is called germination. Different plant seeds often require different treatments to restart their growth process.

Some seeds, such as lettuce, need light for germination, while others must be exposed to chilling temperatures (a few degrees below freezing) for a few days in a moist condition. Other seeds, for example, winter wheat, do not require chilling for germination, but chilling is required for early flowering. Yet other seeds need stratification; that is, they must be buried in moist soil and maintained for weeks or



A barley seed, showing its various parts. (Drawing by Survey Illustrator Lloyd LeMere.)

even months at moderately low tempera ture, say about 42°–50° F. The seed coa of others is water impermeable, and ger mination does not occur until the coat c the seed is weakened. Many of the legum nous trees produce such seeds. It has bee reported that the seeds of the East India lotus (*Nelumbo nucifera*) have remaine ungerminated but viable in the mud of ol ponds for several centuries.

Most seeds, however, require only th presence of water for germination. Man agricultural crops, including many cerea grains, belong to this group. The process o germination has been studied in a numbe of plant species, but probably the bes understood is that of the barley seed, sinc for centuries the beer industry has use germinated barley in the production o malt.

The largest part of a barley seed is it endosperm, which is composed mainly o starchy material and acts as the food re serve. The endosperm is the major con stituent of flour. At one end of the endo sperm is the embryo, which controls th germination process and uses the endo sperm as its source of energy. The endo sperm and embryo are surrounded by a cel layer known as the aleurone layer, which plays an important part in the germina tion process. During the initial uptake o water by the dry dormant seed, the embryo starts its growth process through the re lease of a plant hormone known as gibberellic acid. The plant hormone diffuses outward and enters the aleurone layer where it induces the formation of enzymes required to convert the starchy endosperm to sugars. The conversion of the water-insoluble starch to water-soluble sugars is a very important sequence, since the embryo of the seed cannot use starch directly to produce the energy required for germination.

The key for proper seed germination is the production of hydrolytic enzymes by the aleurone tissue. Much is known about this important process; but the steps leading to the production of enzymes are poorly understood.

Plant physiologist Claus Grunwald is studying the formation of the endoplasmic reticulum (ER); this is the cellular mem-

brane network responsible for the production of the hydrolytic enzyme. The ER in a dormant barley seed is poorly developed, but once germination begins, this membrane network becomes quite prominent. One of the big questions is whether the cellular constituents needed to form the membranes are present (stored) in the seed or have to be synthesized during the very early stages of germination. This is not an easy question to answer, but it is important in the storage of seeds, not only to preserve a high germination rate, but also in the storage of grain for food purposes. The induction of hydrolytic enzymes during grain storage may greatly decrease the nutritional value of the stored seed.

Illinois Raccoon Populations

Now that pelts of raccoons have increased dramatically in value, especially during the past four seasons — from $1.35 in 1970–1971 to $27.25 in 1978–1979 in Illinois — Illinois and several other midwestern states have suddenly become much interested in the raccoon data that Glen C. Sanderson, Head of the Section of Wildlife Research, has collected for the past 24 seasons. This data has been collected at Perardi Brothers Fur and Wool, Inc., Farmington, Fulton County, Illinois. During the 1978–1979 season, Sanderson made five trips to this fur house and examined 472 raccoons.

The low average body weights of young-of-the-year raccoons for the past three seasons are probably explained by high pelt prices that cause previously discarded, very small raccoons to be sold and, thus, weighed. In past years, these pelts were "worthless"; they now bring from $4 to $8 each.

The high percentage of adult females that had not produced offspring observed in 1978–1979 can probably be explained by adverse weather conditions during the breeding season (February) in 1978. For example, in February 1978 the statewide average temperature was 13.5° F below normal compared with 1.7° F below normal in 1977, and the statewide average snowfall was 7.0 inches in February 1978

The raccoon population in Illinois is at an all-time high despite the dramatic increase in prices paid for raccoon pelts. (Photograph by former Survey Photographer W. E. Clark.)

compared with 3.5 inches in February 1977. These conditions probably restricted movements of raccoons enough so that higher-than-average numbers failed to breed.

If the data collected are indices to major changes in the raccoon population, they do not indicate changes in the population in west-central Illinois. However, these data probably would not reflect a major change in the population until the year after the change occurred. The fact that the raccoon harvest in 1978–1979 increased by nearly 22 percent over that for 1977–1978 suggests that Illinois raccoon populations had not declined as drastically prior to 1978 as many hunters and trappers reported.

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Body weights of raccoons vary as much as 1.5 pounds from one year to the next because of weather conditions but have shown no trends during the past 24 seasons. A decline in average weights of sexually mature fur seals that accompanied a population increase was seen as evidence of competition for food. It seems apparent that the present all-time high raccoon population in Illinois is not having problems finding adequate food.

A charge of groups opposed to the use of the leghold trap is that trappers do not run their traps regularly and leave animals to suffer for prolonged periods. During the 1972–1973 season and from 1974–1975 through 1978–1979, the method of taking raccoons — hunting, trapping, or dead on road (DOR) — was noted. During these years, more than 2,000 raccoons killed by hunters weighed an average of 12.0 lb each, and nearly 600 raccoons killed by trappers weighed 11.6 lb each. A preliminary analysis by age and sex indicates that raccoons taken by trappers did not weigh significantly less than raccoons taken by hunters and killed by cars. Thus, Illinois raccoon trappers run their traps often enough so that trapped raccoons do not lose significant amounts of body weight; however, no attempt has been made to determine the length of time required for steel-trapped raccoons to lose a significant amount of weight.

From 1972–1973, when raccoon pelts were worth an average of $5.37 each in Illinois, to 1978–1979, when they were worth $27.25 each, the percentages of raccoons taken by hunters, trappers, and DOR have changed. In 1972–1973 the percentages were 70.9 killed by hunters, 28.0 taken by trappers, and 1.0 DOR. In 1978–1979 the percentages were 78.6 for hunters, 19.6 for trappers, and 1.7 for DOR. Thus, it appears that increased pelt values have resulted in relatively more hunting pressure rather than trapping pressure on raccoons in Illinois.

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NATURAL HISTORY SURVEY REPORTS

Hop Vine Borer in Corn

Several caterpillars, including the European corn borer, black cutworm, common stalk borer, and armyworm, appear almost perennially in Illinois corn and are dealt with rather routinely by growers and entomologists. Other catepillars are more sporadic in their appearance and may cause minor to major yield losses in isolated areas. These sporadic pests occasionally are difficult to identify because of the scarcity of information about them. The hop vine borer, *Hydraecia immanis,* a caterpillar of the family Noctuidae, is a recent example of such an insect.

The hop vine borer feeds in the bases of corn plants during May and June, usually killing the plants in the process. It has become a problem to corn growers in the contiguous areas of Illinois, Iowa, Minnesota, and Wisconsin. Multiple reports of its damage to corn in the Midwest can be traced to the mid-1970's. The Illinois counties in which it has been detected in corn include Boone, Carroll, DeKalb, Ogle, Stark, Stephenson, and Winnebago. The species also has been reported from New York.

The identity of the species became confused when a related species, the potato stem borer (*Hydraecia micacea*), was detected by entomologists in New York in 1975. This species is an Old World caterpillar that inadvertently was introduced into Canada during the late 1890's. It was confined for 75-80 years to the extreme northeastern United States and the eastern maritime provinces of Canada. Its verified appearance in New York was coupled with a nearly simultaneous report of its occurrence in Wisconsin and of a possible third species in Minnesota. The Wisconsin and Minnesota reports were based on tentative examinations of the larval stages of the involved species.

It became apparent that any pest management programs being planned for *Hydraecia* in Illinois and surrounding areas would be greatly aided if the exact number of species involved were known and if their larvae could be easily recognized. Survey entomologist, George L. Godfrey, in cooperation with other entomologists at the Survey, Cornell University, Iowa State University, University of Minnesota, University of Wisconsin, and the

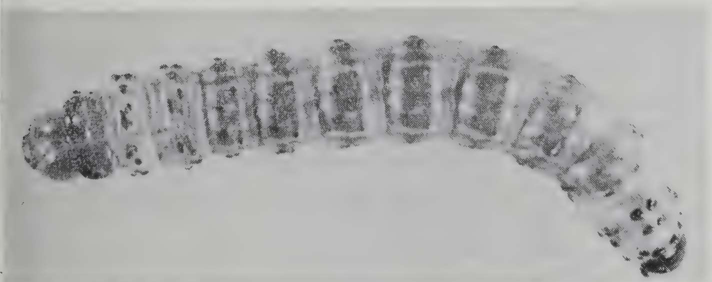


Fig. 1. Fully grown larva of the hop vine borer, *Hydraecia immanis* (Photo by G. L. Godfrey).

Canadian National Collection began a systematic study to clarify the situation.

The efforts established that the hop vine borer is the only *Hydraecia* species presently attacking corn in the Midwest. The confirming evidence will soon appear as a paper by Godfrey in a INHS *Biological Notes*. However, it is reasonable to assume that the potato stem borer, the introduced species, will someday appear in Illinois. The descriptions and illustration in Godfrey's forthcoming publication will help promote its detection if the event occurs.

IPM — New Employment Opportunities in Illinois

Pest scouting is an important tactic in integrated pest management (IPM) and it is currently the most visible activity in IPM. It is providing seasonal and full-time employment for a growing number of people. Pest management consultants, including pest scouts who offer their services for a fee, is a new industry in Illinois. It is an excellent example of a new program begun in the public sector eight years ago, but which is now being adopted by the private sector.

Eight years ago there were no pest management consultants and pest scouts in Illinois. Today there are 18 firms employing 21 full-time pest management consultants and approximately 130 seasonal employees. They are serving slightly over 1200 grower-customers in 86 counties in Illinois. The research and education to support this new industry is supplied by scientists and extension specialists in the Illinois Natural History Survey and the University of Illinois. Research is needed to provide new information and to continually upgrade existing IPM technology. Educational programs transfer this information and technology to the user. The Sixth Crop Protection Workshop for pest management consultants and scouts was held March 11, 12, and 13. The Workshop attracted 372 participants in 1980; 102 more than in 1979. The evening training sessions gave participants the opportunity to identify weeds, insects, and diseases, and to study the application of programmable calculators to pest detection and decision making. The Field Crop Scout Training Program was offered for the 3rd year on April 2-4, 1980. To support these on-campus workshops and schools, four multi-county training sessions will be held in the field during the 1980 crop growing season. These will provide real-world experience for permanent and seasonal employees in IPM. Information on the date, time, and location of these field training sessions can be obtained by writing extension entomologist Donald Kuhlman, IPM Coordinator, 172 Natural Resources Building, Illinois Natural History Survey, Urbana, Illinois 61801.

Illinois growers have developed much interest in integrated pest management and with acreage scouted increasing each year, there is a continuing need for more trained scouts. The major emphasis to date has been on the detection and management of pests in corn and soybeans, but this will undoubtedly expand in the future to include other crops.

Daily Aging of Fish

The age of fish has been determined by counting the annular marks in their bony parts (scales, vertebrae, opercular bones, spines, otoliths, etc.) or by conducting extensive experiments on marking and recapturing of fish. Although the age of fish in years is extremely important to fishery biologists, they have been unable to determine the age of fish from tropical climates (annular marks absent), fish under one year, or fish from disturbed environments such as cooling reservoirs where hot water hinders the production of annular marks. Recently, fisheries biologists have determined that the inner ear bones (organs of equilibrium called otoliths) are composed of layer upon layer of daily rings. These layers have been used to determine daily age of fish and to aid in elucidating life history information such as dates of spawning, growing season, and the effects of environmental conditions on growth rates.

Survey aquatic biologist Bruce D. Taubert studied daily rings in otoliths of fish from North and South America and Africa and has published papers on the technique used to reveal daily rings and the validity

ig. 2. Frontal section of an otolith from a pumpkin-eed sunfish (*Lepomis gibbosus*) showing daily rings ʾhoto by Bruce D. Taubert).

ıf daily rings. In general, most fresh water ish produce the first daily ring in their ıtolith at the time of yok-sac absorption or wim-up. From then on a daily diary is ;ept in the otolith showing daily growth, :hanges in growth rates, and cessation of ;rowth. In young fish the determination of laily age is accurate but as the fish grows ılder events take place that hinder anal-/sis of daily age. Normally, fish stop grow-ng when they spawn, overwinter in emperate climates, or become very old. These events are recorded in the otoliths ɔecause daily ring production stops when ;rowth stops.

To reveal the record of daily and sea-;onal growth in otoliths is as easy as sec-tioning a rock to look at its inner structure and much of the equipment and methods ısed in sectioning otoliths was developed ɔy lapidaryists. After removal from the fish an otolith is secured to a glass microscope slide with a drop of lakeside balsam. In small fish this is all of the preparation necessary and the daily rings can be counted with the aid of a microscope. In young, small fish otoliths are about the size of the eye of a sewing needle. In older and larger fish the otoliths become irregularly shaped and thickened and in order to reveal the daily rings the otolith must be sectioned. The otolith is ground against carborundum paper until a thin section through the center of growth or nucleus is produced, then polished and the rings counted.

In Illinois, Survey biologists are using otoliths to determine basic life history data of fish from Lake Sangchris, Lake Coffeen, and Lake Shelbyville. In Lake Sangchris Survey aquatic biologists Bruce D. Taubert and John A. Tranquilli have used otoliths to reveal life history information about threadfin shad (*Dorosoma petenense*) and largemouth bass (*Micropterus salmoides*). Survey aquatic biologist Ted Stork working on Lake Shelbyville will be using daily rings to determine time of spawning for all species present, and Survey aquatic biologists Lanse Perry and Dennis Newman will be using otoliths to determine previously unavailable information on differences in spawning dates and growth rates of largemouth bass from hot water and ambient areas of Lake Coffeen. These tasks can be accomplished by the otolith method at great savings in time, effort, and equipment.

Cottontails and Grassland

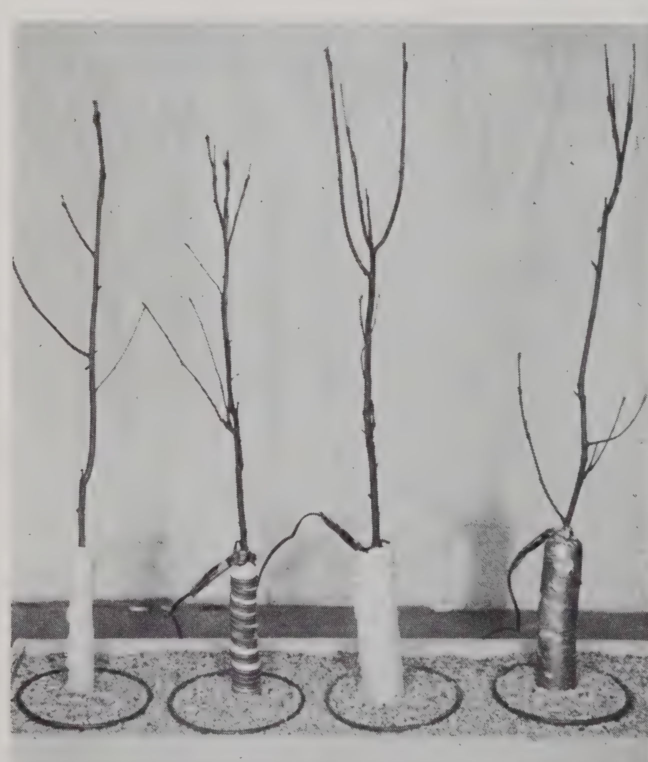
Natural regulation of the abundance of cottontail rabbits is effected through a complex of interacting mechanisms that relate to environmental conditions and events. Trends in statewide abundance reflect the general pattern of events occurring throughout Illinois. Trends in the abundance of local populations can and do differ from the average statewide trends.

Studies of the population dynamics of cottontails conducted since the mid-1950's by Survey ecologist William R. Edwards demonstrate changing patterns of agricultural landuse to be closely associated with changes in cottontail abundance in Illinois. Over the past 25 years the average abundance of cottontails has declined at least 70% statewide, and 90 to 95% throughout most of the intensively farmed central and east-central counties. Roughly 80-85% of

the time a hard freeze occurs, they may suffer from freezing stress. Severe stress causes bud kill, frost collars and cracks, and stem dieback. Less severe stress may weaken plant tissues without actually killing them and result in increased susceptibility to attack by disease organisms. Stem canker and dieback diseases are often associated with freezing stress.

Many studies have been conducted on hardiness to freezing injury in woody plants, but until recently little was known about how freezing affects susceptibility to disease. Information was lacking on the level and duration of freezing required to alter disease susceptibility and whether freezing stress on one portion of a plant would cause other portions to become susceptible. To answer these questions, Survey plant pathologists D. F. Schoeneweiss and E. G. Wene devised a method for differentially freezing whole plant stems under controlled conditions. Portions of stems were wrapped with insulation and heating cables, and those stem parts were maintained above freezing, while adjacent exposed portions were frozen (see photo). When frozen and unfrozen stem portions were inoculated with canker fungi, only those portions subjected to temperatures below zero became susceptible to attack. The fungi were not able to grow into the portions protected against freezing stress.

Apparently freezing stress in woody stems is localized; that is, only stem tissues subjected to freezing temperatures below a critical degree become susceptible to attack by canker fungi. Portions of stems protected by snow cover or mulch may survive hard freezes and not become targets for disease organisms. Since protected stems remain resistant to disease, pruning out portions with canker and dieback symptoms is recommended as a control measure. The remaining plant will usually put out new growth and recover from damage caused by stress-related pathogens. In addition, plants that acclimate quickly in the fall are less likely to be stressed by freezing. Therefore, late season pruning and fertilizing, which delay acclimation, should be avoided.



Portions of tree stems insulated to allow differential freezing (Photo by D. F. Schoeneweiss).

'heasants in Illinois have traditionally been most abundant in the east-central counties (Photo by L. M. David, llinois Department of Conservation).

'all Land Use and the ;urvival of Pheasants

The relative abundance of ring-necked pheasants in east-central Illinois is primarily related to agricultural land use. Research on the Sibley Study Area (SSA) has shown the importance of forage legumes and small grains (particularly oats) for successful nesting and brood rearing by pheasants.

However, relatively little work has been directed toward the relationship of fall land use and the survival of pheasants during the cold season. Trapping and marking studies on the SSA from 1962 through 1965 indicated that the death rate of pheasants, October to February, averaged 75 percent of the early fall population; only 25 percent of these deaths were attributed to hunting. Although survival rates may have been less than average for 1962–1965, these findings illustrate that mortality of pheasants is perhaps greatest during fall and early winter.

Wildlife biologist Richard E. Warner recently completed a statistical analysis of the relationship between fall land use characteristics and the survival of pheasants through late winter on the SSA from 1960 through 1970. The three components of fall land use that were considered in the analysis were acreages of unplowed hay and small grains, unplowed row crop stubble (primarily corn), and plowed farmland.

During the 1960's the amount of land planted to hay and oats declined with the expanded production of corn and soybeans. Fall plowing varied among years in conjunction with weather conditions. Numbers of pheasants on the SSA peaked in the early 1960's, declined substantially from 1963 through 1965, and were relatively stable from 1966 to 1970.

A significant positive relationship was found between acreages of unplowed hay and small grains and densities of pheasants on the SSA in late winter to early spring. However, the correlations do not account for how land use and the reproduction of

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pheasants during the growing season may interact with fall land use and numbers of pheasants that survive through late winter. Thus, correlations of fall land use characteristics with late winter pheasant populations may be primarily a reflection of the importance of a particular cover type to the recruitment of pheasants during the reproductive season.

The correlation coefficients resulting from another analysis suggest that (1) the characteristics of fall land use that were considered in the analysis do not directly explain variations in the number of pheasants that survived on the SSA through late winter, and (2) the significant correlation of the acres of unplowed hay and small grains with late winter densities of pheasants primarily reflects the amounts of hay and oats present during nesting and brood rearing and subsequent recruitment to the fall population.

Although fall land use could not be directly linked to pheasant survival in this analysis, there is little doubt that more subtle — thus far unmeasured — characteristics of fall land use affect rates of pheasant survival on a year-to-year basis.

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NATURAL HISTORY SURVEY REPORTS

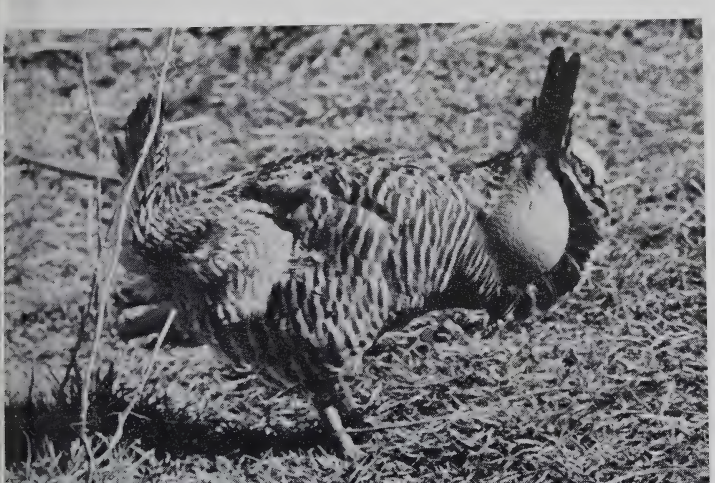
JUNE 1980, NO. [illegible]

rairie and Prairie Chickens

Practically all tillable portions of the ,641 acres now in prairie chicken sanc-ıaries in Illinois had been cultivated nnually for over a century prior to ac-uisition. The one exception, the Walter's 0-acre tract in Jasper County (unplowed nce the mid-1950's), is today covered 5% by native prairie vegetation and 25% y woodland. Three prescribed burns 1974, 1976, and 1979) by wildlife biol-gist R. L. Westemeier and his assistants ıave apparently hastened the spread of ›rairie plants over the Walter's tract. This ract now contains one of the best stands ıf little bluestem (*Andropogon scoparius*) o be found in the south central counties.

Seeded native prairie grasses, mostly witchgrass (*Panicum virgatum*), Indian-grass (*Sorghastrum nutans*), and big blue-tem (*Andropogon gerardi*), are now pre-dominant species on about 157 acres of the 1,001 acres of prairie chicken sanctuaries in Jasper County. Prairie grasses are also started, though not dominant, on another 29 acres. An additional 143 acres are tenta-tively scheduled for establishment of prairie on erodable slopes, waterways, or fields that are not well suited to periodic cropping. Thus, the cover on at least 358 acres (over one-third of the sanctuaries) at Bogota will eventually involve restoration of prairie vegetation.

Although the young stands of native prairie grasses were shown in previous re-ports to be among the poorest cover for nesting prairie chickens with regard to density of hatched nests and percentage success, there are indications that this situ-ation is changing. Nest success in prairie grasses has increased steadily from 25% in 1972 to 75% in 1979 except in 1978 when



Male prairie chicken (Photo by former Survey photog-rapher, W. D. Zehr).

success dropped to 33%. In 1979, the three hatched nests found on the Yeatter Sanctuary were all in fields dominated by prairie grasses. In 1979, prairie grass predominated around the bowls of all of the five nests found in fields where prairie grasses were present. From 1966 to 1978, prairie grass predominated around the nest bowls of only 64% of the nests found in fields with prairie grass.

The increased use of and success in prairie grass by chickens may be due to gradual maturity of stand and improvement in the quality of prairie grass stands. Type of management also appears to be a key factor. Nest densities and nest success were compared in four categories of prairie management: (1) no disturbance, or mowing for (2) weed control (mw), seed (ms), or nesting enhancement (mn), (3) haying, and (4) prescribed burn. Although data for all categories are still limited, results for the mowing category (ms, ms, and mn) compare favorably with nonprairie grass areas. Nest density (nests per 10 acres) and nest success were 2.2 and 50.0% respectively. By contrast, comparable figures for the undisturbed, hayed, and fresh burn categories were 0.9, and 27.3%; 0.4, and 25%; and 0.0, and 0%; respectively.

This is encouraging as prairie restoration seems axiomatic for prairie chickens; however, more data are necessary to confirm the indicated relationship. It would be desirable to try limited grazing with the other approaches to prairie management.

The prairie chicken project is a cooperative project between the Survey and the Department of Conservation, using Pittman-Robertson funds.

The Kankakee River

The Kankakee River, considered to be one of the finest rivers in Illinois, originates near South Bend, Indiana, flows westward into Illinois and joins the Des Plaines River to form the Illinois River. During early settlement of the Kankakee Basin the river was channelized in Indiana to increase flow and facilitate drainage of the land. Modification of the river in Indiana resulted in a fast-flowing ditch that slows markedly when it reaches the more natural, meandering river at the Illinois borde Concern exists among Illinois citizens th sediments washed into the Kankakee Riv in Indiana are deposited as they reach th slower moving Illinois portion of the rive and that these deposits are reducing th diversity and abundance of aquatic life.

Because of this concern, the Illinois In stitute of Natural Resources is funding study by the State's three Scientific Surve on the effects of sedimentation in the Ill nois portion of the Kankakee River. Th Natural History Survey is examining th effects of sedimentation on selected grou of aquatic organisms; emphasis is bein placed on fishes, mussels, midges, aquat beetles, and caddisflies. Information ob tained is being compared to available his torical data and the present and probab future effects of sedimentation in the rive are being evaluated.

The diversity of fishes in the Kankake River is higher than in most Illinois river and because of improved collecting tech niques, is higher now than was indicated i previous studies of the river. Several ex tremely rare species, most notably th northern brook lamprey, pallid shiner, an river redhorse, still are found in the rive

In contrast to the fishes, mussels hav undergone a drastic reduction in diversit and abundance in the Kankakee Rive over the past 70 years. Increased sedimen tation probably contributes significantly t the reduction, although pollution, ove harvesting, and habitat modifications othe than sedimentation also are suspected c causing declines in mussel populations.

Data on insects are still being analyze but the high diversity of aquatic beetle and caddisflies indicate that, as with fishe the Kankakee River is in better conditio than are most rivers in Illinois. The Kan kakee River supports nearly a third mor species of water beetles than does any com parably sized watershed in Illinois. A doze species of caddisflies are known in Illino only from the Kankakee River.

Sedimentation in the Kankakee River a problem and needs to be monitored t prevent further degradation of the rive Among the organisms studied, musse appear to be the most sensitive to sedimen

ation, and they may be ideal organisms to study throughout Illinois to determine the environmental conditions of our rivers.

Hybrid Carp and Aquatic Weeds

As a natural course of events, lakes, ponds and often large reservoirs become heavily infested during warm weather with unsightly growths of aquatic weeds and algae, which ultimately may make waters unsuitable for fishing, swimming, irrigation, or other uses. Aquatic scientists have considered three basic techniques for the removal of nuisance vegetation: chemical herbicides, mechanical harvesters, and various forms of biological control.

The application of chemical herbicides probably has been the most effective and widely used short-term alternative but, since fossil fuels are used in their manufacture, the use of aquatic herbicides are becoming cost prohibitive. In addition, aquatic scientists are uncertain and fearful of specific after-effects of various chemicals on non-target species (both plant and animal). Although considerable work and research has been conducted on mechanical harvesters for aquatic plants, this type of control is also proving costly, and it has not been sufficiently developed for use in certain types of habitats, such as small ponds.

In view of the disadvantages of chemical and mechanical control strategies, the potential for a certain biological agent appears to be very promising. In recent months, the grass carp or white amur (*Ctenopharyngodon idella*) has received a great deal of attention.

Presently the introduction or use of the white amur is illegal in 32 states, including Illinois, due primarily to the paucity of information regarding the fish's natural history, ecology, and its potential impact on wetlands utilized by waterfowl and naturally occurring fish species. Fortunately, recent genetic research in Hungary and the Soviet Union has produced a reportedly sterile carp hybrid which retains the feeding characteristics of the grass carp. That these new fish are incapable of reproducing provides some interesting ramifications for aquatic weed control.

Hybrid grass carp or white amur (Photo by Survey aquatic biologist, Homer Buck).

The opportunity to investigate the efficacy of the hybrid carp as a biological weed control agent for aquatic systems is now at hand for a large multidisciplinary team of aquatic scientists at the Illinois Natural History Survey. The research strategy is designed to compare the hybrid carp and chemical methods as effective means of controlling aquatic vegetation. Following one preliminary year of obtaining baseline data and perfecting methodologies, the team will define a 3-year experimental period of specific effects of the two approaches on the microbial, plankton, benthos, and aquatic plant communities, and on the sport fishery. The study continues one step further by assessing pertinent water physics and chemistry parameters and by determining the functional processes of plant decomposition, the cycling of important nutrients, and the flow of energy moving into and from each component group of the ecosystem. Data gathered from these studies will provide a basis for predictive management practices for both the sport fishery and the hybrid carp. This 4-year project is being supported by Dingell-Johnson funds allocated from the U.S. Fish and Wildlife Service through the Illinois Department of Conservation.

Corn Rootworm Egg Sampling

The northern corn rootworm, *Diabrotica longicornis* (Say), is a pest of corn with the larvae attacking roots and the adults feeding on pollen, silks, and leaves. There is only one generation/year and eggs are laid in the soil during August and September.

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The two practical methods of predicting infestations are sampling for adults and for eggs. There are at least four reasons that sampling for eggs would be advantageous over sampling for adults: the egg stage immediately precedes the stage that causes the most important damage; eggs are stationary; eggs are in the field and available for sampling for an extended period of time (September to May); and sampling for eggs is not affected by time of day, weather conditions, or plant maturity.

Survey entomologists W. G. Ruesink and W. H. Luckmann and research assistant R. E. Foster recently studied the spatial distribution of rootworm eggs and compared five methods of sampling. The maximum depth at which eggs occur was not established since they continued to find them in the deepest samples, but 85% of those found in the upper 20 cm were located in the top 10 cm. Northern corn rootworms show a high degree of preference for oviposition at the plant base, while in the row between plants is of intermediate preference, and the area between rows is least preferred.

Of the five sampling methods only two proved to be reliable. The core method used a sampler similar to a bulb setter. A sample consisted of ten cylindrical cores, 5.4 cm diam and 10 cm deep. These ten cores were sifted through a screen, mixed, and a standard subsample was removed for processing. These samples consisted of plant-base samples (immediately adjacent to the corn stalks) and between-row samples (midway between two rows of corn).

For the frame method all soil was removed from a trench perpendicular to the row and exactly the row width long. To make this task easier, a metal frame 10 cm deep x 10 cm wide x one m long was constructed. This frame was pushed into the ground at the desired location, and all the soil within the frame as long as the row width was removed with a trowel. All soil taken from within the frame was thoroughly mixed, and the standard subsample was removed for processing.

For any sampling program, one of the important questions is how many samples to take. These two methods produce nearly identical levels of reliability for an equal number of samples, but the frame method requires about a third more time. On the other hand, the core method depends on some assumptions about spatial distribution that the frame method does not. Thus the normal core method would be best if the emphasis were on time, and the frame method would be best whenever a high degree of accuracy is desired.

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NATURAL HISTORY SURVEY REPORTS

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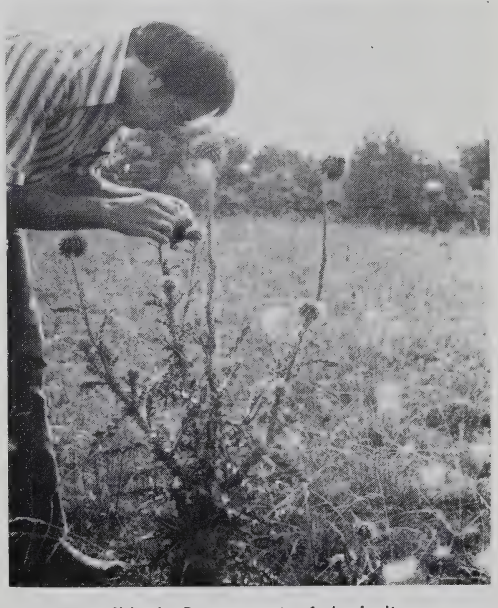
Weevil Released to Control Musk Thistle

The musk thistle is a prickly, bristly weed that grows in large patches in Illinois fields, permanent pastures, and strip mine areas converted to pastures. In June 1979, Illinois Department of Agriculture personnel released about 1,200 adult specimens of the musk thistle weevil, *Rhinocyllus conicus,* at six locations in our state. The collection, release, and monitoring of the weevils was a joint effort of the Illinois Department of Agriculture, the University of Illinois Department of Agronomy, and the Illinois Natural History Survey.

The purpose of these insect releases was to determine whether this weevil could establish permanent populations in Illinois and provide biological control of the musk thistle here. The larvae of this weevil eat the seeds of the musk thistle and thus restrict the plant's reproduction. The adults do a relatively small amount of damage by feeding on the thistle leaves.

About 200 weevils were released at each of six sites near Shawneetown, Gallatin County; Ware, Union County; Edwardsville, Madison County; Cuba, Fulton County; Aledo, Mercer County; and Mor-

The musk thistle weevil, *Rhinocyllus conicus,* on a bull thistle leaf in the laboratory. Photo by James Appleby.



Bill Lewis, Illinois Department of Agriculture, examining a musk thistle for weevil eggs. Photo by Clarence White.

aine Hills State Park, McHenry County. Natural History Survey Economic Entomologist Clarence White has been cooperating with Department of Agriculture personnel by monitoring weevil establishment in the field.

Between May 28 and June 17, 1980, Entomologist White visited each release site with the person who had made the release. Their purpose was to determine how successfully the weevils had overwintered and the extent of their dispersion and egg laying in the spring. At each site a 10-plant sample was inspected for egg masses and adults. They also inspected thistles around the release site to determine how far the weevils had dispersed.

They observed egg masses and adult weevils at five of the six release sites. Thistle plants in their samples had 0-19 egg masses on them, and the averages from the five sites were 4.7-8.3 egg masses per plant. Adult weevils were observed at the release sites and at distances of from ⅛ to ¾ of a mile from the sites.

Only at the Gallatin County site did the researchers find no egg masses or weevils. At that site a herbicide had been used in 1979. Apparently, the weevils' food supply had been eradicated, and no weevils had survived there.

Entomologist White concludes that, with the exception of those released at the Gallatin County site, the weevils overwintered well, dispersed well in the spring and laid many eggs, and are now well established in Illinois. However, White notes that, if our experience is similar to that of western states, the weevils will disperse widely during the next 4-5 years before populations develop that are large enough to exert any important control on the musk thistle.

White-Tailed Deer in East-Central Illinois

White-tailed deer have become abundant in Illinois since their reintroduction in the late 1930's. Harvests of nearly 20,000 deer by 60,000 hunters have occurred in each of the past 2 years. Little is known about the characteristics of deer habitat. To determine these characteristics and to determine how much deer range remains in Illinois and where it occurs, Survey Wildlife Biologists Charles Nixon and Lonnie Hansen and Research Assistant James Chelsvig have begun a cooperative research project with the Department of Conservation dealing with deer ecology and management in Illinois.

Even though winter in Illinois is usually relatively mild, it is a period of stress. The absence of woody cover limits the winter distribution of deer in Illinois, particularly in the central, east-central, and northern counties.

In these counties it has long been known that deer tend to concentrate in localized habitats in winter. In the Rock River watershed, for example, deer moved 10 miles or more to areas along the river in late fall and remained until late March or April, when they returned to their summer range. If such concentrations of deer are found each winter and if the same areas are used each winter, the identification and description of these areas would be of great value in managing Illinois deer.

One area that appears to hold a large winter deer population is Robert Allerton Park in Piatt County. Survey biologists captured 21 deer there in late winter and spring 1980. The deer were captured with a 40- X 50-foot nylon net propelled by rockets, which carry the net over the deer as they feed at a bait pile of corn, apples, and block salt. Most of the deer were marked with collars or ear streamers. Five does were fitted with collars containing small radio transmitters, enabling the biologists to follow the deer and to determine the types of cover deer use at different times of the day.

Minimum seasonal home ranges were calculated for the radio-monitored deer, and they range from 275 to 500 acres during winter and from 75 to 210 acres during summer. During winter, deer were primarily found in dense brushy areas in timber during the day and in wheat or alfalfa fields at night. In the summer, deer make extensive use of cornfields during both day and night. It is believed that part of the reason for using cornfields, aside from their providing good cover, is to escape from the biting insects that are so common in woods.

A fawn captured and marked after biologists located her radio-collared mother. Photo by James Chelsvig.

The distances between winter and summer ranges have been surprising. The radio-monitored deer have moved 4.5-38.0 miles between winter and summer ranges. One yearling buck was seen a mile north of Taylorville, 48.5 miles from where he was marked.

The effects of intensified farming on small game populations, particularly pheasants and rabbits, have received much attention, but there has been less concern about the effects of increased row cropping, fall plowing, and more efficient combines on the availability of deer foods. Corn and soybeans are important fall, winter, and spring foods for deer from central Ohio west to the Great Plains. These high-energy foods are needed for deer to combat harsh winters, when cover is scarce and protection from the weather is limited.

The intensive land use prevalent in Illinois forces deer to adjust their activities to constant disturbance. Understanding how they do this will help the Department of Conservation do a better job of managing Illinois' only big game animal, the white-tailed deer.

New Survey Field Laboratory on Largest U.S. River

The Mississippi River will receive close scrutiny from Illinois Natural History Survey biologists and other scientists during the next 2½ years in a research program tied to the controversial issue of whether a second lock should be built at the new Alton Lock and Dam.

Drs. Kenneth S. Lubinski and H. H. Seagle of the Survey's Aquatic Biology Section will supervise these studies from the Survey's newest field laboratory at Grafton, Illinois, where the Illinois and Mississippi rivers flow together. Appropriately located on the riverfront, the laboratory's two buildings are leased from the Illinois Department of Conservation.

Cooperating with the Natural History Survey in the venture are scientists from the Illinois State Water Survey, Illinois State Geological Survey, and Western Illinois University. Dr. Richard E. Sparks of the Aquatic Biology Section will coordinate the work at Grafton with studies being conducted by five other agencies upstream on the Mississippi near La Crosse, Wisconsin.

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Biologists and hydrologists will join forces at the Grafton Lab to study ways in which barge and pleasure boat traffic affects the Mississippi and the aquatic creatures that call it home. Congress has authorized the Upper Mississippi River Basin Commission to fund this study as part of the 1978 compromise that allowed the construction of one replacement lock for barge traffic at Lock and Dam 26 near Alton. Under this law, the decision on whether to add a second lock — thus increasing barge traffic on the river — must wait until a $12 million Master Management Plan for the river is completed. The plan includes both economic and environmental analyses.

The budget for the research at Grafton is just over half a million dollars. Substantial amounts of state and federal tax money already go to government agencies responsible for the upper Mississippi River: the Fish and Wildlife Service maintains refuges for fish and wildlife; federal and state environmental protection agencies maintain and upgrade water quality; and the U.S. Army Corps of Engineers develops structures for navigation and flood control.

Do these agencies — all working for the same taxpayers — sometimes pull in opposite directions, perhaps without knowing it? For instance, a second lock at Alton *might* increase barge traffic enough that river-bottom sediment would be stirred up in amounts exceeding water quality standards, and these sediments in turn might settle out in a wildlife sanctuary. In such a hypothetical situation, the tax dollars used to improve navigation might then require *more* tax dollars to be spent to undo the effects of the increased barge traffic. It makes sense to spend some money to make sure that each agency can accomplish its work on the Mississippi River without interfering with the work of others.

Once the Grafton project and other studies are finished, the Upper Mississippi River Basin Commission will use the results to decide whether there are any such conflicts, and if so, how to resolve them.

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NATURAL HISTORY SURVEY REPORTS

OCTOBER 1980, NO. 200

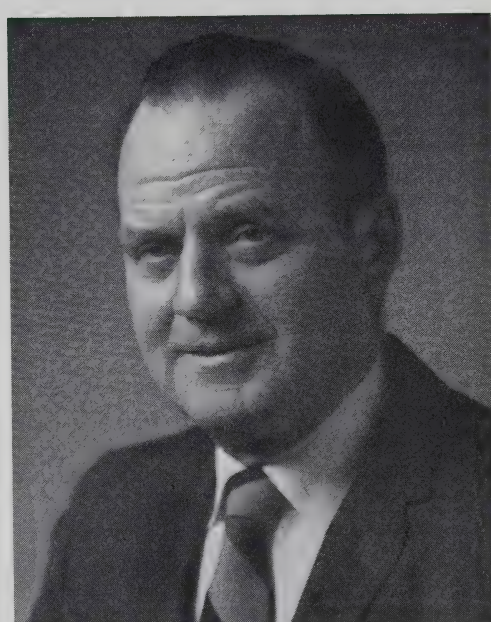
George Sprugel, Jr., Retires Search Underway for New Chief

Dr. George Sprugel, Jr., retired August 31 after 14 years as Chief of the Natural History Survey. Some of the major accomplishments during his tenure were the building and instrumentation of the Natural Resources Annex on the University of Illinois, Urbana-Champaign campus, the development of an extensive grant and contract program, and the expansion of eight field stations in various locations around the state.

Sprugel came to the Survey in 1966 from the National Park Service in Washington, D.C., where he was Chief of the Division of Natural Sciences. Prior to that he was Program Director of Environmental Biology at the then newly formed National Science Foundation in Washington.

He was listed in *American Men and Women of Science, Who's Who in Ecology,* and *Who's Who in America,* and also is a member of many national and international professional organizations. Most recently he was president of the American Institute of Biological Sciences and active in the American Association for the Advancement of Science, and the American Society of Zoologists.

A nationwide search is in progress to select and appoint a new Chief. Dr. Wallace E. LaBerge, Head of the Faunistic Surveys and Insect Identification Section was named Acting Chief by the Board of Natural Resources and Conservation until a permanent appointee is selected. LaBerge also is chairman of the Staff Search Committee that is now interviewing five final candidates for the vacancy. Other members of the committee are Drs. William Childers, William Edwards, Joseph Maddox, and Kenneth Robertson, and Mr. Robert Ellis with Mrs. Alice Adams serving as the group's secretary.



Dr. George Sprugel, Jr., Survey Chief, 1966-1980 (Photo by Larry Farlow, former Survey Photographer).

The committee will present its recommendation on the basis of its activities and solicited input from the entire Survey staff to the Board of Natural Resources and Conservation. The Board has the responsibility of making the final and official

appointment. It is anticipated that the Board's announcement will be forthcoming in the near future.

Mushrooms and Toadstools

A mushroom or toadstool is a fleshy structure that consists of a stalk and a cap with plates of tissue called gills on the underside. The surface of the gills is covered by a layer of cells termed basidia that give rise to the reproductive spores. There is no technical difference between a mushroom and a toadstool as both represent the spore-bearing phases of a fungus. The term mushroom traditionally refers to edible species, some highly prized for their delicious flavors and aromas; and the term toadstool is used for poisonous mushrooms that contain toxic compounds that may cause both illness and death.

Mushrooms can be found throughout most of the year in lawns, roadsides, forests, and prairies. The largest number appear when the first cooling trend of fall is accompanied by rains, usually in September. Warm spring rains also bring out the second largest number of mushrooms including the morels and puffballs.

Edible and poisonous species can occur together and can resemble each other. Thus, safe and toxic species can be confused by amateurs, and there are no quick tests to distinguish the edible from poisonous species. Eating wild mushrooms without learning something about them is like playing Russian roulette. Most of the time nothing will happen, unless a poisonous species is ingested. For this reason, only people familiar with the technical identification of mushrooms should collect and eat wild species.

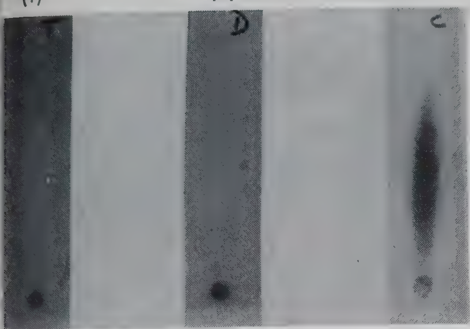
Inedible *Russula emetica* illustrating the stalk, cap and a portion of the gills. Found on rotten wood and rich humus in coniferous forests and bogs (Photo by Leland Crane, Mycologist).

Learning to identify accurately the species that you want to eat as well as those to avoid is the best safeguard. In gathering mushrooms, be careful to collect the entire specimen and keep each kind separate. Collect only fresh specimens for the table; however, young and old specimens may be needed for identification.

Once the identity of a collection is established, check its edibility rating. If the species is rated as poisonous, most people will be poisoned if they eat it. An edible species is one that, when cooked, can be eaten safely in moderate quantities by people in good health. Do not gorge yourself on mushrooms because most people find them hard to digest due to the chitinized walls and the fats and oils in the cells. Eat only cooked mushrooms because certain species are more likely to cause problems when consumed raw than when cooked, and some toxins are inactivated by proper cooking. Do not keep mushrooms for an extended period of time because bacterial contamination may cause food poisoning. Finally, when experimenting with mushrooms, always keep some intact specimens on hand. They may be needed to aid in identification so that the correct treatment can be given in case of accidental poisoning.

Carbofuran in Soils

Insecticides are important tools used in integrated pest management programs for various Illinois crops. Because they are inherently toxic, it is necessary to understand their environmental fate and behavior so that pollution of non-target sites and organisms can be avoided. Knowledge about insecticide behavior also can aid in



elative movement of Counter® (T), dieldrin (D) and arbofuran (C) on thin layer of soil as recorded on -ray film (Photo by Les Woodrum, Survey Photographer).

nore efficiently controlling the target pest. Studies of the behavior and fate of pesticides are called environmental chemodynamics. They are designed to elucidate the relationships between physical and chemical properties of a pesticide and its fate n the environment.

One aspect of environmental chemodynamics is the potential for movement or leaching of a pesticide in the soil. In the Pesticide Chemistry Lab of the Section of Economic Entomology, Allan Felsot and Jean Wilson have studied the mobility of carbofuran (Furadan®), a widely used corn insecticide applied to soil. The studies were performed in the laboratory using a combination of soil, thin-layer chromatography, and autoradiography. Briefly, a soil-water slurry was spread across a glass plate and allowed to dry. Radioactive-labeled carbofuran was spotted on the plate near the bottom end. The bottom edge of the plate was placed in water. The water was allowed to move up the plate to a distance of 10 cm. Afterwards, the plate was covered with a piece of X-ray film for a few weeks, and then the film was processed. Wherever the labeled pesticide was located on the plate, a dark area appeared on the film. The developed X-ray film thus served as a record of pesticide movement under leaching conditions.

Because carbofuran has a relatively high-water solubility compared to other widely used soil insecticides (such as dieldrin and Counter®), it has more potential for movement in the soil. Conversely, chemicals with very low water solubilities (e.g., dieldrin) are adsorbed by the soil matrix to a greater extent and would be expected to exhibit a very low leaching potential. It was observed that carbofuran adsorption by soils was generally one hundred times lower than dieldrin adsorption, and carbofuran consequently was spread across the thin layer of soil while dieldrin was found near the bottom. Thus, as carbofuran adsorption decreased, its leaching potential increased. These results help to explain why similar runoff losses of dieldrin and carbofuran from watershed areas have been observed. Dieldrin is mostly associated with runoff sediment, whereas carbofuran is mostly associated with runoff water.

Lake Michigan Diversion Project

The 300-mile Illinois River stretches from Chicago to Grafton and is blessed with over 100 bottomland lakes and sloughs. These backwater areas make the river unique and once were a paradise for fish and wildlife, and their decline may be accelerated by the Lake Michigan Diversion Project. Stephen P. Havera, Frank C. Bellrose and other wildlife specialists at the Havana Field Station are investigating what effects the proposed, water-diversion project will have on the surface area, volume, and depth of the backwater lakes.

A total surface area of 28,600 hectares (70,670 acres) of bottomland lakes presently occurs in the Illinois River Valley when the river level is at tree line. The Peoria Pool (Peoria to Starved Rock) and LaGrange Pool (LaGrange to Peoria) constitute 85 percent of the area. There is little bottomland area above Starved Rock because of the narrow river valley northward. From Grafton to LaGrange numerous bottomland lakes in the Alton Pool have been eliminated by drainage and leveeing for agricultural purposes. The volume of the bottomland lakes is approximately 144,000 acre-feet. The average depth of the lakes is currently and despairingly only 0.62 m (2.04 ft), primarily because of the high rate of sedimentation from soil erosion on agricultural fields.

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The Lake Michigan Diversion Project will sufficiently increase the surface area and volume of the bottomland lakes in the Illinois River Valley to inundate an undeterminable amount of bottomland timber. Water from Lake Michigan currently is being diverted into the Illinois River at 3,200 cubic feet per second (cfs). The proposed diversion project calls for the rate to be increased to either 6,600 or 10,000 cfs, mainly during the customarily low water periods. However, it is estimated on the basis of a U.S. Army Corps of Engineers' computer model that even during these periods the extra diversion water will adversely affect the bottomland habitat even if the 6,600 cfs rate is selected.

The increased diversion will further accelerate the already extreme rates of sedimentation in the bottomland lakes. The higher water level will allow more sediment to settle in the lakes thereby increasing the rate of fill. If diversion was then discontinued, the average depth of the lakes would be less than if no greater diversion was initiated.

The proposed increased diversion will have the least impact upon bottomland forests, mudflats, and storage capacity of the bottomland lakes in the Upper Pools of the Illinois River Valley because of the greater rate of fall and lack of bottomland areas in the Upper Pools than downstream. The Peoria Pool will be affected the greatest by increased diversion because most of the bottomland lakes are connected directly with the river. Therefore, any fluctuations in river levels will immediately affect the depth, surface area, and volume of the associated bottomland lakes. In the LaGrange and Alton pools, natural and man-made levees protect bottomland areas from some of the fluctuations in river levels. Hence, although changes in depth, surface area, and volume would occur, the effect of increased diversion on bottomland areas in these pools should be less than in the Peoria Pool.

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Underwater Home Movies

Within the Aquatic Biology Section, a great deal of the research is aimed directly at solving important and urgent problems. Water pollution, fisheries management, weed control, and many other problems receive the constant attention of Survey aquatic biologists. In addition to these efforts, scientists also study aspects of aquatic biology which, at first glance, appear to have much less potential for practical application. This first glance, however, can be deceiving.

For example, aquatic biologist Mike Wiley can occasionally be seen standing in the shallow waters of agricultural ditches and small streams around Champaign adjusting one or more tripod-mounted 8-mm movie cameras. The cameras are used to make underwater time-lapse movies of various aquatic insects and other invertebrates. The filming may continue for up to

Time-lapse movie equipment filming aquatic insect behavior in the Middle Fork of the Vermilion River near Flatville. (Photo by Mike Wiley)

3 days, as attached strobe lights fire at 10–30-second intervals, casting a strange, bright, pulsing light on stream banks and adjacent fields at night. By carefully analyzing the films, Wiley can examine the many events and behaviors that together constitute the daily lives of these small aquatic animals.

Why are state-supported scientists engaged in such seemingly peculiar studies? Just as a mechanic who doesn't understand how an engine works cannot do a good job of diagnosing and repairing it, aquatic biologists cannot provide information and guidance on complex environmental issues unless they first understand how aquatic organisms and communities function. By studying the behavior of aquatic invertebrates, biologists like Mike Wiley find answers to such basic questions as: How do these animals live? What do they eat? How much food is available?

From the answers to these basic questions comes an understanding of what determines the size and distribution of various invertebrate populations. The small invertebrates living in our creeks and drains provide the food for many larger insects and minnows, which in turn are eaten by sport fish, such as bass and catfish. Improving our management of sport fishes, then, depends upon a fairly sophisticated understanding of the insect populations on which the fishes feed.

All of the sections of the Natural History Survey maintain programs in basic as well as applied research. They do so because understanding how nature works is an important prerequisite to working with nature and getting nature to work with us. Even though basic research often appears strangely impractical at first glance, it is important to remember that, like underwater home movies of insects, these studies are often essential to our knowledgeable use of our state's living natural resources.

Poisonous Plants

The word "poison" is often used with plants when only the word "caution" is warranted. Quite a number of plants can cause discomfort, pain, or illness, but few are lethal. The three types of injuries caused by plants are internal poisoning, dermatitis, and allergy.

Although many kinds of mushrooms are perfectly safe to eat, some are extremely toxic, and only a few bites can kill an adult. Some flowering plants also are potentially dangerous. The most important ones found in the wild in Illinois include pokeweed (*Phytolacca americana*), poison hemlock (*Conium maculatum*), water hemlock (*Cicuta maculata*), nightshade (*Solanum* species), and jimson weed (*Datura stramonium*). A few garden plants are also toxic, including yew (*Taxus* species), lily-of-the-valley (*Convallaria majalis*), daphne (*Daphne mezereum*), the leaf blades of rhubarb (*Rheum rhaponticum*), and castor bean (*Ricinus communis*).

Children, because of their inquisitive nature and tendency to put things in their mouths, are especially apt accidentally to ingest plant materials.

The most frequent cause of plant-induced irritation of the skin is poison ivy (*Rhus radicans,* also called *Toxicodendron radicans*), which is abundant throughout Illinois. A few other plants can cause dermatitis, including poison sumac (*Rhus vernix*), trumpet creeper (*Campsis radicans*), and some spurges and poinsettia (*Euphorbia* species). Stinging nettle (*Urtica dioica*) and wood nettle (*Laportea cordata*) have stinging hairs that cause immediate, intense pain; one or both of these plants are found almost anywhere in Illinois. Some plants cause dermatitis in an indirect manner by making a person hypersensitive to light. For example, areas of the skin that come into contact with wild parsnip (*Pastinaca sativa*) and are then exposed to sunlight can develop symptoms similar to those caused by poison ivy. The situation is different with a number of other plants, where hypersensitivity results only when the plant is eaten; this phenomenon is not well understood, and fortunately, few people are affected.

A fairly large number of people suffer from allergic reactions to plants. Certain people are allergic to particular plant foods, such as wheat, flour, beans, tomatoes, chocolate, nuts, corn, and peanuts. "Hay fever" is an allergic reaction to

Poison ivy, *Rhus radicans.* Several other plants have similar leaves, but until you learn to distinguish them, abide by the old adage, "Leaflets three, let it be." (Photo by Kenneth R. Robertson)

microscopic airborne pollen and spores. In Illinois, there are three peak seasons for hay fever. In early spring, much pollen is shed by many common trees, such as ash, birch, elm, maple, oak, poplar, and sycamore. Many of the wild, yard, and crop grasses flower in midsummer, causing another peak in the pollen count, but the greatest amount occurs in fall when ragweed and a few other weeds shed tremendous quantities of pollen.

A great deal of other interesting information about plants is included in the recently published Illinois Natural History Survey Circular 55, *Observing, Photographing, and Collecting Plants,* by Kenneth R. Robertson. A copy may be obtained by writing to the Illinois Natural History Survey, Natural Resources Building, Champaign, Illinois 61820.

Serendipitous Entomologist Makes Discovery

Serendipity is not one of the abilities which scientists must have to be employed at the Natural History Survey. However, the "gift for finding valuable or agreeable things not sought for," as Webster defines serendipity, is always welcome. A case in point is that of economic entomologist Robert J. Barney, who in the spring of 1979 was studying the migration of the alfalfa weevil and its predators into and out of alfalfa fields.

As a part of this study, Barney placed pitfall traps along the edge of an alfalfa field 2 miles south of Lively Grove, Washington County, and 13-17 meters into a woods of oak with some hickory interspersed that bordered the field. The traps were made of galvanized metal guttering cut into 1-meter lengths and fitted with end caps. The pitfall traps were set in the ground flush with the soil surface and were half filled with ethylene glycol. Any insects that walked up to the traps would fall into them and be preserved there. The trapped insects were regularly removed and identified.

Trapping was begun on May 15. Imagine Barney's surprise on June 13 when he discovered that his traps contained specimens of a dung beetle, or tumble bug, that had never before been found in Illinois.

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This beetle, *Deltochilum gibbosum gibbosum,* was previously known from Florida, Georgia, Alabama, Mississippi, Louisiana, North Carolina, South Carolina, Texas, Tennessee, and southeastern Kentucky. Its discovery in southwestern Illinois extended its known range by over 100 miles.

More than 70 percent of the beetles trapped were found between June 13 and July 3. The ratio of females to males was 2 to 1. These beetles were found in both the field-edge and the woods traps, most being found in the woods.

The Natural History Survey is charged with the responsibilities of identifying the insects and other animals of the state and publishing reports on them. Usually these kinds of work are very straightforward activities. But once in a while even scientists like to enjoy a little serendipity.

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NATURAL HISTORY
SURVEY REPORTS

DECEMBER 1980, NO. 207

ˌquaculture, Potential New Industry ɔr Illinois

Aquaculture, the practice of growing quatic organisms in freshwater systems, ppears feasible, practical and potentially rofitable in Illinois. Catfish, trout, carp nd prawns are some of the organisms that ave been grown successfully in the state. \ literature study recently completed by Robert Gordon, INHS, and Randy Westgren, University of Illinois Agricultural Economics, and funded by the Institute of Natural Resources has shown that the echnology for aquaculture is now well developed for various culture methods including raceways, silos, cage and pond culture. Farm ponds, reservoirs, strip mining akes, cooling lakes and streams are suitable systems for various types of aquaculture.

Types of organisms, stocking rates, types of feed, growth rates, diseases, environmental problems, harvesting methods and marketing problems have been or are now

Prawn grown in Illinois (Photo by Homer D. Buck, Aquatic Biologist).

being studied. These results suggest that good aquaculture businesses may expect profits ranging from $625 to $1,250 per hectare per year when raising catfish which sell for $2.80/lb retail. Profits may vary according to the individual system in use. Small operations are less likely to be profitable than are larger systems due to various fixed costs. Catfish ponds of 20-acre size with multiple ponds are recommended. Costs for construction, personnel, equipment, land, buildings, advertising and processing have a direct impact on the success of any operation as do disease and wise aquaculture practices.

Our studies suggest that by good management practices, hard work and perseverance, a farmer can show a profit in aquaculture within a few years under current conditions. As the number of aquaculture systems and the markets for aquaculture products increase, the data suggest that greater profits will be realized in aquaculture in Illinois.

In Illinois ca. 100-200 acres of water are currently known to be used for the culture of commercial catfish. Fishout ponds in use may raise this number to 300 acres. By contrast, Arkansas (12,000) and Mississippi (25,000) are the leading states in acreage registered for the production of catfish. The largest population centers in Mississippi range from 40,000 to 260,000 while the populations of St. Louis and Chicago are approximately 2 and 7 million people respectively. Thus, the market potential for aquaculture products in Illinois far surpasses that of the southern states.

The more rapid growth of catfish in southern climates may be offset by the increased costs of transportation of aquaculture products to northern markets. Catfish can be grown to marketable size (i.e., 1.5 lb) in Mississippi in 2 growing seasons while 3 seasons are required in Illinois.

Overall the prognosis for aquaculture as a viable branch of agriculture in Illinois is good to encouraging. The technology is available now and is improving. With the initiation of a government program to stimulate the development of aquaculture through the U.S.A., coupled with the potential markets in the regions, there are substantial opportunities for investments in aquaculture in Illinois.

Sampling Methods in Soybean Entomology

A source book entitled *Sampling Methods in Soybean Entomology* recently was published under the co-editorship of Marcos Kogan, Section of Economic Entomology, INHS, and Agricultural Entomology, University of Illinois, and D. C. Herzog, Department of Entomology and Nematology, University of Florida. It is the first synthesis of techniques and study results on sampling arthropod populations for a specific crop. The book is designed to promote quality research on soybean-associated arthropods and to help integrated pest management (IPM) specialists objectively evaluate local insect problems. However, Kogan points out that it is not a control manual.

The dramatic increase in the level of soybean production in Illinois and elsewhere in the world since the 60's brought with it a need for more entomological research. One program that was created to fill this vacuum is the U.S.D.A.-sponsored "Regional Project S-74: Tactics and Management Systems for Arthropod Pests of Soybean." The Survey and the University of Illinois participate in the project along with several other institutions.

Kogan recognized the need to standardize the methods being used to sample the populations of soybean arthropods, especially in the research of determining levels at which insects can cause economic dam- age and in evaluating effectiveness of bio- logical control agents. He proposed th idea to the S-74 participants in 1976 emphasizing the necessity of being able t compare the results of research from on state to another.

Kogan and Herzog, as co-editors worke with 30 authors from various state, na tional, and foreign programs in order t comprehensively cover the subject of soy bean entomology. Authors from the Surve and the University of Illinois beside Kogan are C. E. Eastman, C. G. Helm M. E. Irwin, W. G. Ruesink, and G. P Waldbauer. Besides emphasizing samplin methods, the book is a compilation of in formation on the distributions, life historie and nature of damage of commonly en countered soybean pests. L. D. Newson points out in his forwarding comments tha the book's coverage is sufficient to mak "control procedures possible for most o the world's major arthropod pests of soy beans."

Persons interested in copies of *Samplin Methods in Soybean Entomology* ma order them from the publisher, Springer Verlag, New York.

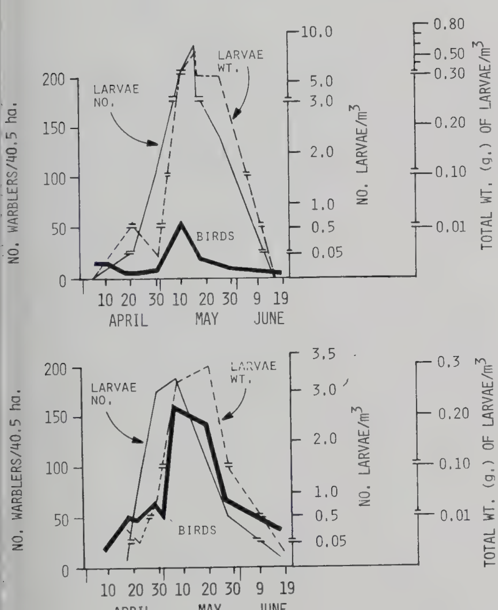
Migrant Warblers and Illinois Forests

The people of the United States, b treaty with Canada and Mexico, hav agreed to protect nearly all species o migratory birds. In practice the degree o protection varies from country to countr and, in the United States at least, fror species to species. For species of waterfow food and relatively large areas of habita are provided the birds during their stay i the U.S.A. While hunting of some water fowl is allowed, the populations are mea sured each year, and strict limits are place on the numbers killed to insure sustainin populations of each species.

Protection of migratory non-game bird has been limited mainly to making i illegal to purposely kill them, though man thousands are killed accidentally each yea on television towers and other structure The over-all effect of that mortality is un known. Potentially more serious is the fac

that there are no specific habitat refuges for most non-game species and no restrictions on habitat destruction. Even more serious is the fact that there have been no systematic measurements of migrant songbird populations, and, except in a very general way, there is little knowledge of habitat and food requirements or food availability for these species. To find out more precisely how many migrant birds are using Illinois forests, Survey ornithologists Jean and Richard Graber began in 1979 to make daily censuses of migrants in four arboreal habitats: bottomland forest, upland forest, shrub and forest-edge, and pines. Because many migrants are insectivorous, a concurrent study was initiated on food availability in the same habitats. With 2 years of field work completed, the researchers are now analyzing data on the wood warblers (Parulidae), one of the most numerous and most beautiful groups of birds in Illinois.

At the peak of spring migration the densities of warblers in bottomland forest were about 5 times the breeding populations. How does the forest accommodate such numbers? The answer appears to be



Numbers of warblers, numbers of insect larvae (Lepidoptera) and biomass of larvae during 1980 spring migration in upland forest (top graph) and bottomland forest (bottom graph) in southern Illinois.

that the migrants coordinate their arrival to the time when insects are most abundant. The insect censuses revealed that over 96 percent of the invertebrate biomass on forest foliage in spring was larvae (mainly Lepidoptera), and virtually every time the Grabers observed a warbler with food, the food item (prey) was a caterpillar-like larva. The peak of warbler migration coincided with the peaks of both numbers and bio-mass of insect larvae. A similar matching curve (not shown) was found for all species of arboreal foliage gleaners, except the tiny sylviids (kinglets) which peak early in the larvae season, possibly to catch the earliest (smallest) caterpillars.

The population of migrant warblers was more than 3 times greater in bottomland than in upland forest. It is perhaps not surprising then that the peak insect larval population in the upland was twice that of the bottomland forest. Although it is tempting to try and draw conclusions about the effect of the warblers on caterpillar populations, much more study is needed on such questions as annual variation in all populations, on the warblers' foraging rates and other activity patterns, on the warblers' particular choice of prey and the particular availability of that prey, the nutritional value of the prey, etc., before doing so. That work is continuing, but for now the data emphasize the importance of bottomland habitats not only to our nesting species but also to the migrants, coming and going. With conventional agricultural methods, it is relatively easy to provide grain for visiting waterfowl, but for most of our transient species there is no other way to meet their requirements than to preserve the natural habitats that sustain them.

Horse Flies and Deer Flies

The tabanids or horse and deer flies are well known to dairy farmers and livestock producers as well as to campers, fishermen and outdoor enthusiasts as annoying and often painful inhabitants of most wooded areas in Illinois. These large and persistent flies impart a painful bite and can occur

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in sufficient numbers to make canoeing and hiking virtually impossible.

Tabanids are vectors of several diseases of man and animals caused by viruses, bacteria, rickettsia or rickettsia-like organisms, trypanosomes and filarial worms. Although some diseases transmitted by tabanids occur in Illinois, only anaplasmosis is a reasonably common occurrence in the spring and fall, but basically is found only in southern Illinois.

From 1978-1980, a faunal study of the horse and deer flies of Illinois was carried out by survey entomologist Donald W. Webb with field collecting done by Edward A. Lisowski. The study, which is part of an ongoing faunal study of several groups of flies in Illinois, resulted in the collection of over 15,000 specimens.

The collecting program concentrated on the peripheral counties, particularly in the marshes and swamps of southern Illinois; sand marshes of Iroquois County, sphagnum bogs, dunes and marshes of Lake and McHenry counties; and along the Illinois River and Mississippi lowlands of western and northwestern Illinois. Since female deer flies readily attack man, specimens were easily caught with an aerial net as they swarmed around the collector's head. Horse flies which are more mobile and attack man less voraciously than deer flies were collected in Malaise traps (8 x 60 ft piece of insect netting strung across paths and fire lanes). Malaise traps were located at special locales in Pope, Mason and Ogle counties to provide information on the seasonal flight patterns of various species.

On the basis of the recently collected material and previous holdings of horse and deer flies in the collection of the Survey's Section of Faunistic Surveys and Insect Identification, 86 species and subspecies definitely are found in Illinois. An additional 23 species are known to occur in the surrounding states and have a strong likelihood of occurring in Illinois.

A manuscript on the adult tabanids of Illinois has been completed in cooperation with Dr. L. L. Pechuman, Cornell University. In addition, Dr. H. Teskey of the Biosystematic Research Institute, Agriculture Canada, has cooperated in providing descriptions, illustrations and keys to the larval stages of Illinois tabanids. The published bulletin on the horse and deer flies will provide keys to the males and females of each species, as well as to the known larvae, and will give descriptions of their diagnostic characters, emergence periods, distributions and biologies.

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NATURAL HISTORY SURVEY REPORTS

JANUARY 1981, NO. [illegible]

Clear-cutting and Gray Squirrels

Before 1960, foresters used single-tree or small-group cutting to harvest trees in the eastern hardwood forests. Such limited cutting did not seriously affect gray squirrels if less than 50 percent of the merchantable volume of trees was removed. Since 1960, research has demonstrated that eastern hardwoods cannot be reproduced with satisfactory composition by the use of single-tree harvesting. Instead, clear-cutting, which completely removes woody stems larger than 2 inches diameter at breast height (dbh), has been found to produce stands well stocked with commercially valuable species.

Obviously, complete tree removal will also remove tree-dwelling wildlife, including gray squirrels. Foresters and wildlife biologists need information regarding the constraints on timber harvesting, such as the size of clear-cuttings, that are necessary to perpetuate wildlife species that are adversely affected by the practice.

Survey wildlife biologist Charles M. Nixon and his co-workers in Ohio have just completed an 8-year investigation of the effects on gray squirrel populations of clear-cutting mature hardwoods, using clear-cuttings varying in size from 5.7 to 32 acres and in age from 0 to 22 years. On two study areas, gray squirrels were trapped and marked for 2 years before clear-cut logging to investigate the influence of these cuttings on squirrel densities, individual movements, and recovery rates. Four additional small clear-cuttings, 7-9, 15-17 (two areas), and 20-22 years old, were used to determine squirrel presence and squirrel food production up to 22 years after logging.

They found that captures of gray squirrels declined 51.5 percent and estimated densities declined 44 percent in the first year following the clear-cutting of 32 acres of the best hardwoods within a 206-acre study area. Recovery rates for marked adult gray squirrels whose home ranges included the clear-cutting were lower than rates for adults not exposed to clear-cutting. Fewer than 20 percent of the adult squirrels known to be living adjacent to the clear-cut area were captured within the cut area in the first 2 years after cutting.

In a companion study of two smaller, narrower clear-cuttings (9.4 and 19.5 acres) on a 188-acre stand of hardwoods, no significant changes in squirrel densities, recovery rates, breeding rates, movements, or body weights were observed after clear-cutting. The recovery rate for adult females was significantly higher on this area compared with that of females on the area with the 32-acre cutting.

On these cuttings and the older ones studied (7, 15, and 22 years old), squirrels ventured significantly farther into a clear-cutting during winter than after leaves appeared. Clear-cuttings less than 22 years old contained less food for squirrels than did uncut forests. Thus, gray squirrels using cuttings less than 22 years old were considered to be transients, but they did forage significantly farther into 15- and 20-year-old clear-cuttings than into the 7-year cutting.

A recent clear-cutting of hardwoods in the Midwest. All woody stems greater than 2 inches in diameter are cut to allow rapid growth of new seedlings and stump sprouts.

At least two characteristics may render 1- and 2-year-old clear-cuttings unacceptable habitat for foraging gray squirrels. First, logging residues and the luxuriant growth of annual forbs restrict the squirrels' ability to detect predators. Even in winter squirrels in clear-cuttings traveled mostly on downed tree limbs, rarely venturing to the ground.

A second reason why squirrels may avoid a recent clear-cutting is the lack of staple foods. No winter-storable foods were produced until 15 years after cutting. Squirrel foods were particularly scarce during the first two growing seasons, when only fungi, flowering dogwood drupes, and grapes were produced in quantity.

It was apparent from these studies that large (more than 30 acres) clear-cuttings must be avoided if wildlife species that prefer mature hardwood habitats are to survive.

Therefore, in considering a size limitation on clear-cuttings, the home range of the adult female gray squirrel was used as a guide toward minimizing the effects of clear-cutting on this species. A mean home range of 5.2 acres was found for adult females livetrapped on three study areas in southeastern Ohio a minimum of eight times during 2 or more years ($N = 51$). The diameter of a circle encompassing an area of this size is about 530 feet. Clear-cuttings kept narrower than this distanc should allow most squirrels to retain som portion of their original home range anc should enhance their chances to tolerat the logging operation.

The length of narrow clear-cutting will be determined by site-class differences topography, logging constraints, or con flicts with travel and stream protectio zones. If cutting units exceed 20 acres, th wildlife biologists recommend retention o uncut travel lanes of mature trees, 50-10 yards wide, to permit squirrels and othe wildlife to cross clear-cuttings. These trave lanes would be required for about 30 year after cutting to allow trees within clear cuttings to reach seed-producing age Travel lanes should be cut selectively, us ing single-tree or small-group cuttings t perpetuate a stand capable of producin at least 100 pounds of winter-storable foo per acre. Recommendations for the amoun of shelter necessary to maintain huntabl numbers of gray squirrels are not docu mented, but in Illinois, gray squirrels wer not present in stands with fewer tha three tree cavities per acre.

Because of extensive cutting betwee 1890 and 1935 in the eastern hardwoods most stands are now approaching commer cial maturity. Foresters and wildlife man agers thus have an opportunity — one tha will not occur again for a whole timbe

otation (80-120 years) — to begin adusting timber age-classes in most forests.

Yields of both timber and gray squirrels an be maintained through long-term planing of cuttings over large units of forest. Jse of small (less than 20 acres), narrow less than 530 feet), carefully located clearuttings in forests where 40-60 percent of he stands are retained in a seed-producing ge should not materially reduce gray quirrel populations.

Cutting-Rot Susceptibility

The propagation of softwood cuttings is in important method for producing many andscape tree and shrub species. A mist propagation technique involves the mechanical spraying of water over leafy cuttings to maintain a thin film of water on the plant tissues. The high humidity promoted by mist, and its cooling effect on plant foliage, allows the propagator to expose cuttings to full sunlight without fear of leaf wilt. During the mist propagation phase, softwood cuttings are especially susceptible to attack by fungal pathogens. *Pythium, Phytophthora,* and *Rhizoctonia* are three genera of pathogens often implicated in the cutting-rot problem.

Economic losses from pathogen attack during propagation can be considerable, since thousands of adjacent cuttings may be involved. More serious is the problem of diseased rooted cuttings being transferred to the field with latent infections. These plants are likely to decline or die when later exposed to such stresses as transporting shock, poor drainage, or unfavorable weather. Very little research has focused on pathogen-host species interactions during propagation. Mary Ann Smith and Dan Neely, Survey plant pathologists, have completed a study that evaluated the disease reaction of 16 woody host plants to the three pathogens.

Results of the screening tests indicated that plant species had markedly different levels of susceptibility to the three cutting-rot pathogens. In 40 percent of the combinations, severe cutting rot developed. In 15 percent of the combinations the plants exhibited no disease symptoms. In many of the combinations the plant survived infections by producing a well developed root system above a basal rot lesion.

As shown in the table, smoke tree, deutzia, buckthorn, and sumac were highly susceptible to all three pathogens. Only privet exhibited low susceptibility to all of the pathogens.

This research established the ability of fungal isolates from three genera to cause disease on 16 woody plant species. The patterns of development of basal rot, root rot, foliar necrosis, and defoliation were defined. This information will be helpful to propagators and nurserymen in diagnosing and treating the disease problems encountered with mist bed operations.

Relative susceptibility of cuttings to inoculation with three genera of fungal pathogens.

Cutting	Rhizoctonia	Phytophthora	Pythium
Red ozier dogwood	High	Low	Low
Smoke tree	High	High	High
Cotoneaster	Moderate	High	Low
Deutzia	High	High	High
Winged euonymus	Moderate	Low	Moderate
Forsythia	Low	Moderate	Moderate
English ivy	Moderate	Moderate	Low
Privet	Low	Low	Low
Honeysuckle	Moderate	Low	Low
Star magnolia	High	High	Moderate
Bayberry	High	High	Low
Buckthorn	High	High	High
Jetbead	Moderate	High	High
Sumac	High	High	High
Alpine currant	Moderate	High	Moderate
Dwarf cranberry	Moderate	Low	Moderate

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Survey Scientist Participates In International Exchange

International exchange of information has become increasingly important in aquatic biology, as foreign fishes, such as the Chinese carps and Nile perch, are brought to this country with little understanding of the impact they may have on our natural ecosystems. As an example of attempts to extend international contacts with biologists, R. Weldon Larimore of the Survey's Aquatic Biology Section has recently participated in a Fulbright lectureship at the University of Nis, Yugoslavia, where he delivered a series of lectures and worked with a group of graduate engineers on the effects of impounding a small stream in northeastern Yugoslavia. Expected changes in water quality and in the biological communities above, below, and within the impoundment were considered. Larimore and his group formulated a long-range plan for the development of the sport fishery in this area that is intensively used by Yugoslavs for rest and recreation.

On his way to Yugoslavia, Larimore spent several days with biologists at the Fishery Research Station, Szarvas, Hungary. Scientists at this station are doing advanced work in fish culture, fish genetics, and the use of animal wastes in fish production. Their work on the grass carp and its hybrids has been of particular interest to American biologists because of the potential of this fish for controlling aquatic weeds in this country. Survey aquatic biologists Homer Buck and David Philipp have cooperated with the Hungarian biologists on this work and were pleased to have new information gathered personally by Larimore. Larimore also visited the Hungarian Institute of Limnology and discussed with scientists their studies of exploitation of lake fishes and the potential for further commercial production.

In western Yugoslavia, Larimore visited several large fish farms and led a discussion at the University of Zagreb concerning environmental laws and their economic impacts in eastern Europe and America.

Larimore's visit to eastern Europe has stimulated further activities between foreign and Natural History Survey scientists. Not only are Survey biologists in closer contact with the foreign projects, but in the near future two biologists from Yugoslavia and one from Hungary will come to Illinois to exchange ideas with Survey scientists.

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NATURAL HISTORY SURVEY REPORTS

FEBRUARY 1981, NO. 204

Caddisfly Egg Toxicity Bioassay

What are the effects of insecticide and herbicide runoff from farm fields in Illinois on the embryological development of aquatic insects? To answer this question Illinois Natural History Survey biologists David Belluck and John Unzicker along with University of Illinois graduate Barbara Pennington selected the pond dwelling caddisfly *Triaenodes tardus* Milne (Trichoptera: Leptoceridae) as a representative aquatic insect. A new toxicological test, the caddisfly egg toxicity bioassay which used the eggs of *T. tardus*, was developed to study the effects of pesticides on the egg development of this common Illinois caddisfly.

T. tardus is widely distributed in North America. It is transcontinental in Canada and the northern United States and extends north into Alaska. In the central and southern United States it occurs from the east coast west to the Rocky Mountains. The aquatic stages are found in lakes, ponds, marshes and in areas of slow current and in medium to large rivers where they are always associated with vascular plants from which they construct a case of spirally arranged leaf fragments.

Egg mass of the caddisfly, *Triaenodes tardus*, used for toxicological bioassay research.

During the summers of 1979 and 1980, 40 pesticides were screened for ovicidal activity using the caddisfly egg toxicity bioassay. To obtain eggs for this test, gravid females of *T. tardus* were attracted to an ultraviolet light trap set up within 90 min. of darkness at the Illinois Natural History Survey research ponds. Females were captured with an aspirator and transported to the laboratory where their extruded egg masses were removed with a forceps and placed in a cup of filtered pond water. Egg masses were then placed in prepared solutions of pesticides and stored on shelves at a constant temperature of approximately 26°C. An experiment was terminated with the successful hatch or death of the last egg in the egg mass (usually between 2 to 3 weeks after oviposition).

Analysis of the toxic effects of selected insecticides and herbicides on the egg development of the caddisfly *T. tardus* indicates that these animals are very sensitive to the presence of pesticides in solution. Toxicity levels varied within and between different classes of insecticides and herbicides. Herbicides were found to be toxic to

eggs of *T. tardus* from 1.26 parts per million to 114.30 parts per trillion, and insecticides were toxic from 2.90 parts per million to less than 10 parts per trillion.

While it is difficult to accurately predict the toxic effects of pesticides to organisms in the field from laboratory derived data, tests such as the caddisfly egg toxicity bioassay attempt to bridge such gaps. Laboratory exposure of field-captured aquatic insect eggs to toxicants can show the potential effects of a particular chemical upon those organisms if the chemical was to be applied in the field. Additionally, the low cost and simplicity of the caddisfly egg toxicity bioassay permits organizations with limited budgets and/or staff expertise to conduct toxicity tests on a local basis.

Migratory Peregrine Falcons

Survey biologists William W. Cochran and Arlo Raim conducted studies of migratory peregrine falcons in the spring and fall of 1979. Transient migrants, monitored with miniature radio transmitters, spent up to one month in southern Texas (Brownsville area) before continuing their spring migration. During an 8-day winter survey in southern Texas, only one peregrine was sighted. By contrast, in the April study no fewer than 4 and an average of 7 peregrines were sighted per day over the 1-month period. The spring/winter ratio of sightings (56:1) supports the view that the 15-bird spring sample was of transients.

The northward headings from southern Texas raised some questions as to the wintering areas of the observed peregrines because there is relatively little land directly south of Brownsville. Migrant peregrines reaching southern Texas from South America and most of Central America would have to travel considerably northwest, not north. Thus, it may be concluded that a migratory direction change takes place for some peregrines after they reach southern Texas, based on the census data showing only few winter residents of the area.

Banding and visual data verify a significant "turn" in migration for only a few bird species. One example is the whistling swan, which heads NNW from its Chesapeake Bay wintering site to favorable feeding areas in the Ontario-Michigan (Detroit) region where it spends several weeks. It then departs almost straight west for the Dakotas where it remains for several more weeks before again switching direction significantly to the NNW.

For the swan it can be shown that the stops occur where shallow-water habitat is favorable for feeding. Peregrines can probably do well enough anywhere they can find prey species. However, the southern Texas area, and especially the barrier islands, have considerably more prey than the comparatively barren areas of western Texas and northeastern New Mexico which northwest-bound peregrines would reach if they continued on the course that brought them to southern Texas. Thus, it is a good place to make a turn to the north where prey is available. However, it is not known why the peregrines layover in southern Texas until May. Perhaps the turn is not a "behavioral" change in the "method or cues" for orientation. If the cues are celestial, they must be given time to change. For example, during April the sunset direction is moving quite rapidly clockwise to the north. From April 4 to April 27 this change amounts to 11 degrees which is in the needed direction but only one-half to one-third the change that the peregrines must make if all the turn is made during this interval and in southern Texas.

The fall studies, based on a sample of 10, showed that transient peregrines trapped on Assateague Island continued their magration in a variety of directions from SE to SSW. There is also weak evidence that many of these migrants spend up to 2 or perhaps 3 weeks along the coast before proceeding. One of the study birds spent at least 10 days on Assateague before heading south. It is known from band-return information that peregrines reach Assateague from directions ranging from NW to NNE. This virtually precludes any solid comment based on a small sample.

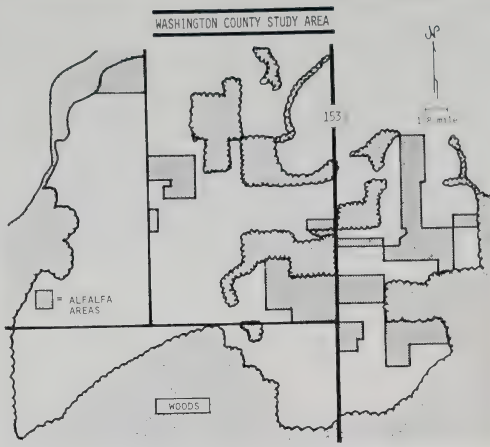
Alfalfa Weevil Migration

The alfalfa weevil has been the most common and destructive pest of alfalfa in

Illinois for nearly two decades. The damage is done primarily by the larvae feeding on the tender growing tips of the alfalfa plant for three or four weeks in the spring. When the larvae are fully grown they spin silken cocoons on the plants or in the ground litter and pupate. The pupae transform into adults in one or two weeks which, after feeding briefly in the spring, migrate to protected areas (particularly wooded areas) in the vicinity of the alfalfa fields where they enter a resting period called aestivation. In Illinois, most of the adults will return to the alfalfa fields in late summer and early fall.

For the past several years, two Survey entomologists, Robert D. Pausch and Stephen J. Roberts have been studying the movement of adult alfalfa weevils in and out of alfalfa fields in Washington County in southern Illinois. The studies have resulted in a better understanding of this pest of alfalfa and have produced a new concept of pesticide usage. Pausch and Roberts have shown that the migration of the adult weevil into alfalfa fields after leaving their sites of aestivation is first a gradual movement across the soil surface. Flight occurs only after the weevils have been in the field for a considerable length of time and have been able to restore their depleted energy resources by feeding. Because of the delayed flight activity, the majority of the weevil population is concentrated in a relatively narrow band at the edge of the alfalfa fields and is in a relatively immobile state. These conditions argue well for controlling the fall adult weevil population with insecticides.

Pausch and Roberts currently have research underway to more fully investigate various ways of controlling the alfalfa weevil with a fall, adult-control program. Preliminary tests in the development of this new concept have been encouraging. Two fields of approximately the same size and with approximately the same size populations of alfalfa weevils were used to test the idea. A 60 ft-wide perimeter band of one field was sprayed with an insecticide at a time when the Survey researchers estimated that the majority of the weevil population was contained within the band.



Study area of alfalfa weevil migration and control in southern Illinois.

The second field was left unsprayed and served as a control. Both fields were monitored very closely the following spring to follow the development of the weevil larvae. In the unsprayed control field, the weevil population developed to the point where the field had to be sprayed for the larvae or else the entire first cutting would have been lost. The larval population in the sprayed test field remained low, and an excellent first cutting of alfalfa was made without applying any additional insecticide.

It must be pointed out that although the first trial of this new concept of alfalfa weevil control was encouraging, more research needs to be done. To this end, entomologists Pausch and Roberts have expanded the scope of their research and will be studying the effectiveness of different application rates of selected insecticides, band widths, and timing of application in various areas of the state.

Aquatic Biology Training Programs

Many on-the-job training experiences are available for college students in the Survey's Section of Aquatic Biology. These experiences are in field and laboratory work involving fish, aquatic insects, plankton, bacteria and habitat analysis. The training programs usually include a variety of technical tasks so the students receive broad exposure to work in the aquatic sciences.

Students from several universities and

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colleges have taken advantage of the training opportunities. Some have used their experiences toward requirements for a college degree; others simply to prepare themselves for a job by applying their college 'book learning' to real world problems. From the University of Illinois, graduate and undergraduate students have crossed the Urbana campus to take part in Survey aquatic research. Many have prepared theses under the guidance of Survey scientists.

More students in recent years have come from Eastern Illinois University than from any other school. In 1972, Dr. Leonard Durham, Director of Life Sciences at EIU, established an active Environmental Biology Program and the following year included in it a requirement that each student must serve a 12-week internship in a professional environmental institution. EIU students have interned in many parts of the country and in many kinds of work with governmental and business agencies. Since the program was begun at EIU 8 years ago, 310 students have taken part in the training opportunities and 124 of these have been associated with the Survey. Many other schools in Illinois and in other states now have similar programs for their students and are sending their interns to work at the Survey.

Students are given some financial aid for their work at the Survey, but the major benefit, besides the small salary and college credits, is the improved eligibility for employment. Even a few months of professional association in biology make the student much more attractive to an employer who expects that his/her staff can face and solve present day problems. Interns from the Survey program have enjoyed spectacular job opportunities in many areas of environmental biology.

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NATURAL HISTORY SURVEY REPORTS

MARCH 1981, NO. 205

Radar Studies of Bird Migration

For every bird which regards Illinois as its home, several others pass through this centrally located region on their way to breeding grounds. However, modern land-use practices seem to be reducing the habitats available to birds which depend upon Illinois for resting areas on their annual flights. The bottomland lakes of the Illinois River, once a prime resting and feeding habitat for ducks and other water birds, are being filled with silt eroded off agricultural fields (INHS Reports No. 200). While the land area of Illinois is certainly large, suitable habitats for many species of migrant birds are steadily disappearing, as woodlots, hedgerows, and riverbank forests give way to man's use of the land. Recent investigations by Richard Graber and Jean Graber of the Wildlife Research Section (INHS Reports No. 202) suggest that peak periods of migration may result in a "no-vacancy" situation in which small birds occupy almost all of the available forest habitat during their stopovers.

Because most species of migrating birds fly at night (the hawks, swallows, and others we see in the daytime constitute the exceptions rather than the rule), the time-tested methods of the field biologist do not

Common nocturnal migrants through Illinois, thrushes of the genus *Catharus* have been the subject of radio-tracking studies at the Illinois Natural History Survey. The distinctive thrush wing pattern may be useful in identifying them in migratory flight with radar and the tracking telescope. (Photograph by R. R. Graber)

give the full picture of avian migration. A bird seeking a hospitable place to come down often does so in the dark hours before dawn, out of reach of the sharp eyes of the field investigator.

Thus, researchers have turned to less direct methods to document the behavior of migrating birds. Chief among these is radar; even small birds can be electronically followed through the night in this way, almost certainly without their knowing that they are being tracked. In 1981 Ronald Larkin of the Wildlife Research Section will begin studies in Illinois using a radar unit which has been specially modified for use by biologists.

Some of the most basic questions about bird migration remain open, including how birds navigate from wintering to breeding grounds and back, distances often measuring thousands of miles. Other puzzles include social relations and flocking during migration — birds migrating at night are usually detected flying alone yet are often seen in flocks on stopovers.

Much of its potential for helping to answer questions like these is presently lost because radar gives almost no information on the kind of bird which is being followed. Only its general size and flight speed give clues as to the species. In a new attempt to overcome this limitation, Larkin is testing a tracking telescope and spotlight used in conjunction with radar, for the first time giving the investigator a look at the animal under study. This effort promises to pay large dividends in our basic understanding of bird migration.

The possibility that birds flying over Illinois may have difficulty finding grounds for resting and feeding is also the subject of radar investigations. Using the ability of radar to reach out over thousands of yards and track an individual bird, the researcher can study birds that are descending at the end of a night's migration and selecting a place to spend the day. Radar can also be used to count birds coming into an isolated woodlot, in order to assess the size of periodic influxes of migrants into shrinking patches of habitat.

Surprising Benefits Possible from Nonchemical Alfalfa Weevil Controls

During the past few decades several bio logical and cultural methods of agricultura insect pest control have been conceived However, farmers have relied heavily o the use of synthetic chemical pesticide largely because they achieve satisfactor control at relatively low cost. Unfortu nately, the extensive use of synthetic or ganic pesticides has had detrimental effect on the environment.

Luis Zavaleta and William Ruesink, Sur vey economic entomologists, have investi gated the potential benefits that might aris from the use of biological controls as wel as from the introduction of a host plan with added resistance to the alfalfa weevi (*Hypera postica*). This insect is one of th more important insect pests of alfalfa and can cause significant losses in yield or even the death of the crop.

Their study used computerized model previously developed for the alfalfa crop and for the alfalfa weevil. The dynamic computer model of the alfalfa crop mim icked the daily time path of state vari ables, such as the biomass of leaves, stems buds, and total nonstructural carbohy drates as a function of environmental con ditions. The model simulated other condi tions, such as the harvesting of the crop its regrowth, and new material generated by photosynthesis. The rates of flow be tween components and the rate of photo synthesis were modeled as functions of light intensity, day lengths, temperatures, and the values of the state variables. The model assumed adequate moisture, high levels of fertility, and the absence of pest problems other than the alfalfa weevil. Dynamic computer models of the life cycles of the alfalfa weevil and the parasite (*Bathyplectes curculionis,* a small parasitic wasp which lays eggs inside weevil larvae) were also established.

Both models, the alfalfa plant growth and the insect component, were interfaced through the feeding process. The potential rate of feeding by the weevil was modeled as proportional to the average developmental rate per life stage, but this rate

varied from day to day with temperature variations. The interaction between the parasite and the weevil larvae was modeled through the process denoted attack. Through this process, a certain percentage of the larval population in the second stage was parasitized and remained so during the third and fourth stages, dying during the latter. The beneficial effects of the parasite were obtained through an induced reduction of feeding rates for the larval stages of the weevil and through an increase in its mortality rate.

For this analysis, records of 10 years were used for each of four weather stations, selected as representative of major alfalfa growing regions in the eastern United States: Ithaca, New York; Bedford, Virginia; Rochester, Minnesota; and Nashville, Illinois. For the period of analysis, daily maximum and minimum temperatures and solar radiation were required.

The model was given its initial values and set in motion as of September 1, because at that time most alfalfa weevils are diapausing adults. In the simulation runs for each locality, the initial weevil density was set at ten per square meter, typical of a moderately heavy infestation. In those cases where parasites were included, their initial density was set at two per square meter, a rather low population level for that species. These initial conditions were used in the simulation models to provide results that may be considered conservative.

Finally, the model recorded an insecticide application whenever the density of third and fourth instar weevil larvae exceeded 400 per square meter, corresponding approximately to the economic injury level recommended in Illinois.

Changes in yield, insecticide use, and their monetary values were computed by comparing 10-year averages for a normative bench-mark solution, the application of chemicals, to averages obtained for different elements integrated in pest management methods. The results thus obtained were used to measure the benefits that might be derived from integrating (a) biological and chemical controls and (b) biological, cultural, and chemical practices.

The alfalfa weevil (*Hypera postica*) can cause significant losses in yield or even the death of the crop. (Photograph by J. S. Ayars)

The researchers found that the integrated approach improved yields by reducing the damage, compared with those values reached by chemical control only, and it also reduced the amount of insecticide required.

When the data were evaluated for the eastern United States, they suggested that the parasite could save about $44 million per year as compared with the bench-mark case. This predicted increase in production represents less than 1 percent of the total crop, and it would not be expected to influence the market price for alfalfa hay. In addition, this approach could account for a great reduction in pesticide use. About 1,100 fewer tons per year of insecticide would be necessary than when only chemical control is employed. This reduction in pesticide input to the environment deserves attention far beyond its economic value, Zavaleta and Ruesink point out.

Another method of pest management is the use of cultural practices. These practices may involve, among others, adjusting the date of harvest and introducing plants that are genetically resistant to the weevil. Presently, however, no commercially available alfalfa varieties have resistance to the alfalfa weevil. Zavaleta's and Ruesink's analysis was performed to quantify the value of resistance, and the results should provide plant breeders with the incentive

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to develop varieties with even a small amount of resistance.

The type of resistance considered here is known as antibiosis, in which some characteristic of the plant causes a reduction in the survival of the pest population. Specifically, 20-, 40-, 60-, and 100-percent additional mortality levels were evaluated.

The use of a truly resistant plant — one on which the pest can not (or will not) live, represented here by the 100-percent added mortality case — would increase average yields to a total value of $89 million per year. At the same time, insecticide use would be reduced to zero.

If breeders achieved only 60-percent added larval mortality, insecticide use still would decline to zero, but a small amount of damage to alfalfa would continue to occur. Under these conditions the damage is too slight to justify the expense of insecticide application. Thus, 60-percent added mortality would be nearly as beneficial as 100 percent.

If 40-percent added mortality were attained, the value of production would increase by $61 million per year, and insecticide use would decrease by 3,743 tons annually. In this case, some insecticide would still be used in the Midwest, but the use rate would be 85 percent below the present rate. East of the Allegheny Mountains, because of differences in the eastern and western weevil populations, no insecticide would be needed.

Finally, if only 20-percent mortality were added to the first larval instar, the value of production in the eastern United States could be increased by $30 million per year, and annual insecticide use could decrease by 2,260 tons. Although these figures are far inferior to those of the 40-percent case, producers and environmentalists would welcome this dramatic improvement.

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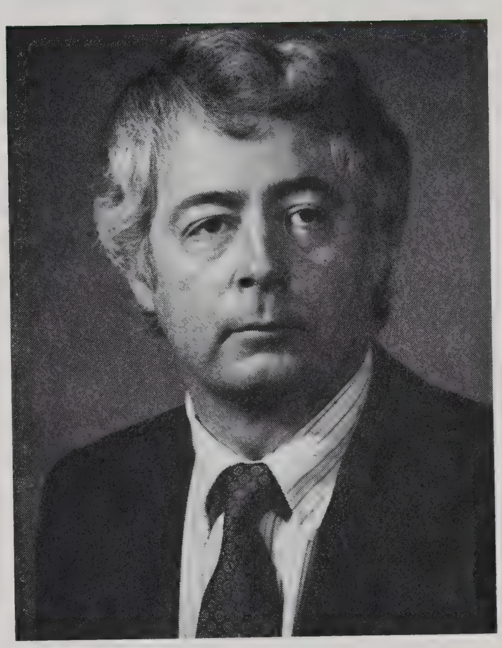
NATURAL HISTORY SURVEY REPORTS

APRIL 1981, NO. 206

Paul G. Risser, Appointed Chief of the Survey



Dr. Paul G. Risser, new Survey Chief. (Photo by Les Woodrum, Survey Photographer)

Dr. Paul G. Risser has been appointed Chief of the Natural History Survey by the Board of Natural Resources and Conservation. He currently is Chairman of the Department of Botany and Microbiology, University of Oklahoma. Risser officially will assume his new administrative responsibilities on June 1, 1981, and will succeed Dr. George Sprugel, Jr., who retired on August 30 last year. During the interim, Dr. Wallace E. LaBerge has served as Acting Chief.

Risser's selection by the Board followed a thorough screening process by the Staff Search Committee that examined and interviewed qualified applicants from the USA and Canada (see October 1980 issue of **Natural History Survey Reports**). The formal announcement was made by Director Frank Beal of the Illinois Institute of Natural Resources who serves as the Board's chairman.

The new Chief will bring to the Survey an immense wealth of administrative experience and proven leadership in the areas of environmental research and survey related activities. Prior to the appointment as chairman of his department at the University of Oklahoma in 1978, Risser served as Program Director of Ecosystem Studies for the National Science Foundation, Director of the Oklahoma Biological Survey, and Assistant Director of the Oklahoma Biological Station. One of his colleagues remarked that he brought national recognition to the Oklahoma Biological Survey by turning it into a viable program for the State of Oklahoma.

As a leader in environmental biology and plant ecology he has participated on various national and international committees and delegations. His national associations have been with the National Science Foundation, Smithsonian Institution, Interagency Federal Committee on Ecological Reserves, and the U.S. Fish and Wildlife Service. Internationally he has been involved with the International Biological Program, a U.S. delegation to the Soviet Union for discussions of biosphere

reserves and ecosystem analyses; and various meetings in France and Switzerland under the auspices of UNESCO, UNEP, and IUCN.

Risser is a graduate of the University of Wisconsin where he was awarded a PhD in Botany in 1967. His productive scientific career as a plant ecologist has centered on the analysis of plant communities and the assessment of environmental changes on plant ecoystems. As Chief of the Survey he is planning to maintain an active research program in addition to administering the diverse programs of the Survey. This will take considerable effort but as one observer noted, Risser has a great capacity for organization and work.

Risser applied for the position of Chief because of the highly regarded national reputation of the Survey and its programs. He considers the Survey to be the finest institution of its type and welcomes the association with it and its high quality research endeavors which, he stated, coincide with his own scientific and intellectual interests.

The staff of the Survey is very supportive of Risser's appointment as Chief and is anticipating a productive and stimulating association with him.

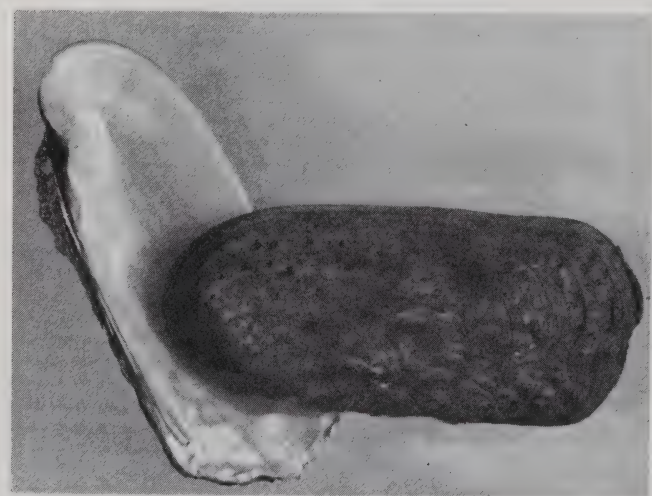
Clams of the Vermilion River System

The freshwater mussel (clam) fauna in eastern North America is the richest in the world; approximately half of the known species of freshwater mussels occu in this defined geographical region. Th quantity of mussels found in rivers fron Wisconsin to Alabama is equalled almos nowhere else in the world.

Mussels are a unique source of commer cial and aesthetic value. Their shells ar used as the basic raw material in the pro duction of cultured pearls in Japan Several species are very sensitive to change in water quality and serve as valuabl indicators of environmental changes.

In Illinois, a variety of aquatic habitat support a diverse and abundant musse fauna. However, recent surveys indicat that serious depletions of both numbers o individuals and species of mussels are oc curring in Illinois. John Suloway, a mem ber of the Section of Aquatic Biology, an Liane Suloway, a member of the Sectio of Faunistic Surveys and Insect Identifica tion, have been contracted by the Illinoi Department of Conservation to determin the status of mussels in the Vermilion Rive system (Wabash River basin) in easter Illinois.

The major objectives of the study ar (1) to determine the number of individual and number of species of mussels at ap proximately 30 sites in the Vermilion Rive system, (2) to compare this data with his torical information, (3) to correlate th changes in mussel communities wit changes in substrate and water quality, an (4) to aid the Department of Conserva



Quadrula cylindrica, also called th rabbit's foot, a rare mussel (clam found in the Vermilion River i eastern Illinois. (Photo by Les Wood rum, Survey Photographer)

ion in the establishment of criteria for atural areas in Illinois.

Twenty-two species of mussels were colected in 1980. The North Fork at present upports the highest densities and diversiies of mussels in the Vermilion River sysem. Several species collected in 1980 are incommon in Illinois, and at least two of hese species, *Obovaria subrotunda* and *Quadrula cylindrica*, are restricted to the Ohio River basin in Illinois. *Quadrula cyindrica* is considered rare and endangered n the U.S.A. by some experts.

Thirty-two species of mussels have been ound in the Vermilion River system since he turn of the century. Between 1960 and 1980, the number of species collected delined from 25 to 22 with a concurrent 61 percent reduction in number of individuals collected.

This investigation will be completed by July 1, 1981. During the spring of 1981, collections will be made at approximately six additional stations. The entire data base of chemical, physical and biological results will be analyzed and synthesized in the final report to the Department of Conservation.

Aphid Nose Knows

Did you ever wonder exactly how those aphids managed to find your favorite rose bush or get into your house and find that prized plant and what that might have to do with an aphid's "nose"?

Most aphids are rather fussy feeders and to accommodate this fussiness they have evolved some complex behavior and developmental patterns. Let's look at the common aphid on rose, *Macrosiphum rosae*. That rose bush in your front yard was completely free of aphids after you sprayed it last year but by mid-June of this year it will be covered with aphids again. Where did they come from and how did they get to your rose? They came from another, perhaps distant, rose somewhere. During the winter months this species survives as eggs laid on the stems of rose bushes. The hatch will be from early April in southern Illinois to late April in the

Apterous viviparae (wingless adults that give birth to live nymphs) and nymphs of the rose aphid, *Macrosiphum rosae*, on cultivated rose. (Photo by David Voegtlin, Assistant Taxonomist)

northern part of the state. This generation, called the fundatrices, will mature in about two weeks and almost immediately will begin giving birth to live aphids which will grow and reach maturity in another two weeks. These generations are wingless and confined to the host plant. It doesn't take long for the original rose plant to become very crowded, especially after two or three generations. Crowding does interesting things to aphids and plants. Under heavy feeding pressure from the aphids, the plant may become very weakened, wilt and die. The aphids can sense this, possibly through the quality of the sap they are sucking from the plant, and they can also detect their crowded living conditions. In response to one or both of these stimuli the next generation develops wings.

When the winged forms are fully developed, other roses become fair game. These winged aphids leave their crowded, dying home, fly up and are carried away by the wind. They will continue to fly until some physiological demand is satisfied and then will slowly descend toward the ground. The amount of time spent in the air will vary from less than an hour to an entire day. With a moderate wind speed a considerable distance may be covered. As the aphids near the ground they will have a variety of plants to land on. They may in fact have landed in the middle of a

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square mile of corn or soybeans, and our fussy rose aphid absolutely refuses to feed on these plants. How does it know they aren't roses. The nose — we finally got back to the nose — will tell them.

Aphids can't see very well, and although they are quite good at colors they seem to rely on close-up taste tests for final judgment. After landing from an extended flight, the aphid will place its rostrum (nose) against the plant surface, and from this rostrum tiny stylets will probe the plant and taste it. There are sensors on the tip of the rostrum and quite possibly some associated with the stylets. Positive or negative stimuli will trigger further responses. If there are negative stimuli our aphid will launch itself again and again until it finds a rose. There is usually a tremendous mortality to aphids during this time, but there are always a few who happen to find the preferred host, your rose bush, well fertilized, with swollen flower buds and a veritable aphid feast.

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NATURAL HISTORY SURVEY REPORTS

MAY 1981 NO. 20[illegible]

Pheasant Nest Habitat Along Rural Roads

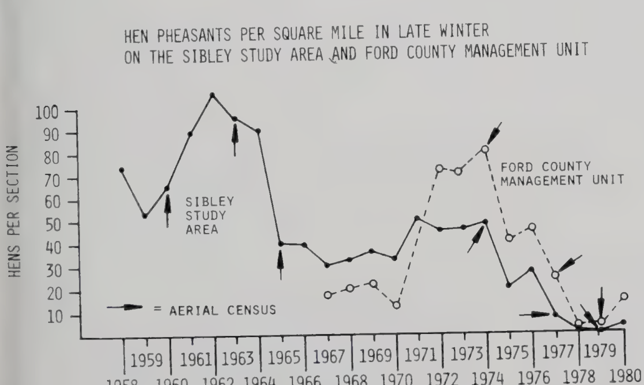
From 1962 to 1977 changes in agricultural land use in Illinois pheasant range resulted in the loss of approximately 54 percent (2.4 million acres) of the hay and small-grain acreages and 45 percent (1.8 million acres) of uncultivated farmland to row-crop production. In addition, during this period approximately 2 million acres of farmland were converted to nonagricultural uses in the counties that sustain self-maintaining populations of pheasants — the northern two-thirds of Illinois.

The loss of habitat for reproduction and the clean farming practices associated with row-crop production have been almost cataclysmic developments for pheasants and native ground-nesting wildlife.

Wildlife biologist Richard E. Warner has been evaluating roadside management by the Department of Conservation (DOC) in east-central Illinois as a program that may in part mitigate the loss of nest habitat. The Ford County Management Unit (FCMU) was established in 1968; 61 of the 65 farmers on the 20-square-mile area allowed the DOC to establish a combination of bromegrass and alfalfa along roadsides and agreed to delay mowing annually until August 1.

Nest studies conducted on the FCMU since 1973 have indicated that more than half of the juvenile pheasants recruited into the fall population typically hatch in developed roadside vegetation. Late winter and spring indices of relative abundance suggest that when the roadside vegetation became established after 1970, the numbers of ringnecks on the FCMU increased substantially over those of the premanagement era (1967–1970). Moreover, since approximately 1971, pheasants have been more abundant on the FCMU than on the reference area near Sibley.

Although pheasant populations on the FCMU have maintained a margin of abundance over those of the reference area, roadside management has not mitigated the deleterious effects of intensified agriculture in the 1970's or the decimation of



The relative abundance of hen pheasants on the Ford County Management Unit and the nearby Sibley Study Area.

ringneck populations by winter storms in January 1977 and during the winter of 1977–1978. However, censuses conducted in 1980 indicate that recovery from recent storm-related declines may be enhanced by roadside management.

Although most research on the FCMU has been directed toward pheasants, nest studies have also encompassed ground-nesting songbirds. Preliminary analyses indicate that these species have responded to roadside management in a manner similar to that documented for ringneck populations.

Mississippi Navigation Effects on Macroinvertebrates

One of the major tasks of a research effort to determine the effects of navigation on the aquatic resources of the Mississippi River got off to an enthusiastic start this past summer. Dick Seagle and Jeff Hutton, Survey aquatic biologists, and Rick Anderson and Deborah Leibig of Western Illinois University began work to determine the effects of river navigation on the drift of aquatic insects and other small organisms, collectively referred to as macroinvertebrates. The first phase of the study, which began in June, involved selecting representative sampling sites and testing field methods and gear.

Pool 26, located near Alton, Illinois, is where the Illinois River enters the Mississippi. Of the commercial river traffic passing through Pool 26, about 60 percent moves down the Illinois River, and about 40 percent comes down the Mississippi above the Illinois confluence. Thus, Pool 26 offered the unique opportunity to study the effects of different levels of barge traffic on aquatic resources in a single pool. Based on physical similarity, three sites, corresponding to the three levels of traffic, were chosen for intensive biological sampling: sites 1 and 2, Mississippi River miles 211.5 and 219.7; site 3, Illinois River mile 3.

The second phase of the summer's work was to describe the distribution, abundance, and drift rates of aquatic macroinvertebrates at the three sites and to establish a base of information from which to work. Drift, a natural phenomenon, is defined as the entry into the water column and the downstream movement of invertebrates. Most aquatic invertebrates exhibit some sort of drift periodicity, and some groups, e.g., mayflies, flies, and caddisflies occur in extremely high numbers at night. Drift is important in the aquatic ecosystem because it regulates invertebrate populations, supplies organisms to recolonize stressed areas, and is an important food source for fish and other aquatic species. One of the reasons for including drift research in a navigation-effects study is that barges and large pleasure craft can vastly alter water pressure and velocity when they pass a certain point in the river. It has been hypothesized that these pressure and velocity changes are great enough to dislodge organisms from the substrate, thus inducing drift. Induced drift and altered drift rates could seriously affect invertebrate populations and the species that depend on them for food.

The macroinvertebrate community was sampled with a ponar dredge, artificial substrates (rock-filled baskets placed on the river bottom), and "bongo" drift nets. Though the usual substrates in the Illinois River (silt-clay) and Mississippi River (sand) are different, ponar samples indicated small standing crops of macroinvertebrates and few species in both systems. The average number of specimens per dredge sample for both rivers was generally less than 20, and the average number of species never exceeded five. The macroinvertebrate community in the Mississippi River was dominated by midges, caddisflies, mayflies, and worms. Dominant forms in the Illinois River were worms and midges.

Artificial substrates in the Mississippi River were placed on wing dams (submerged rock dikes extending into the channel to train the river flow). These areas provide a good substrate for colonization, typically exhibit high macroinvertebrate productivity, and are likely to be affected by water pressure and velocity changes generated by barges. Artificial substrates in the Mississippi River had by far the greatest average number of specimens (2,421) and the highest average of species (16) of macroinvertebrates. Illinois River

Natural History Survey researchers are attempting to learn how towboats (like this one on the Illinois River at Beardstown) affect the drift of aquatic insects and other small organisms. (Photo from a slide by W. C. Starrett)

artificial substrates were subjected to heavy siltation and averaged only 291 animals and six species.

The number of species and animals collected per unit of time in drift-net samples was lowest at Mississippi River mile 211.5. The other drift-net sampling sites (Illinois River mile 3 and Mississippi River mile 219.7) produced at least twice the number of animals and more species. Drift-net samples taken off the two types of substrates (sand-silt and rock) were similar in the Illinois River. Phantom midges dominated the samples, and at times net-spinning caddisflies, mayflies, and hydra were common. Drift-net samples off of wing dams at both Mississippi River sites were somewhat similar to one another. Phantom midges, net-spinning caddisflies, mayflies, and hydra were the dominant forms. Sand-silt substrate drift was dominated by mayflies, hydra, and phantom midges. Drift densities (number per cubic meter) at all sites were always higher at night than in the day, and highest drift densities were recorded at 1:00 and 4:30 a.m.

Air Pollution and Illinois Agriculture

Many people are increasingly concerned about the variety, quantity, and pervasiveness of materials which are added to the environment. These include gases, particulates, agricultural chemicals, and radioactive materials added to the atmosphere; sewage and chemicals to water systems; and solid wastes to the land. Environmental pollutants, acting individually and together, affect man's food supply, health, and well-being, sometimes adversely. Indeed, clean air is not the normal environment for plant and animal growth in many locations. Air pollution, or "smog," is usually identified with large metropolitan areas, such as New York, Chicago, Denver, and Los Angeles. However, scientists are aware of and often disturbed by the apparent increase of air pollutants in nonmetropolitan and rural areas whose economic base is frequently agricultural.

Growing plants, whether in a garden, ornamental landscape, or agricultural field, exist simultaneously in both air and soil environments and are particularly susceptible to environmental pollution. Vegetation is especially important because light energy is captured and transformed to chemical energy by photosynthesis. As a result of this activity, plants are pivotal for food production and the support of food webs.

For some time, environmental quality

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has been a major interest of Natural History Survey scientists, who conduct research on the renewable natural resources of the state. The Survey's participation in environmental studies has been broadened to include plant-air pollution interactions. Anton G. Endress of the Botany and Plant Pathology Section is constructing a chamber system to examine the effects of exposure to air pollutants on the development, growth, yield, and quality of plants. These studies emphasize the acidic gaseous pollutants — sulfur dioxide (SO_2), nitrogen oxides (NO_x), and hydrogen chloride (HCl) — which are produced by the burning of coal or refuse for heat and power needs. There are indications that the concentrations in the air of certain pollutants will increase in the future mainly due to the combined pressures for relaxation of air-quality standards and the increased use of domestic coal.

Endress and two colleagues, Claus Grunwald and Donald F. Schoeneweiss, are currently initiating a study of soybean growth and development as it is affected by SO_2. Soybeans were chosen because Illinois is the U.S. leader in soybean production, and several studies have shown that soybeans are sensitive to air quality.

The Survey scientists emphasize that injury to vegetation was one of the earliest manifestations of air pollution and has been a subject of study for over a centur Most studies have concentrated on injur symptoms of leaves, which consist of var ious types of pigmented, chlorotic, or ne crotic markings. Growth and yield reduc tions caused by air pollutants have als been known for some time and are recog nized as widespread problems. Yield losse have occurred when leaves showed visibl markings. In the last few years, howeve yield losses from air pollutants have bee reported without any visible injury to th crop. For example, last year scientists fror the Argonne National Laboratory i northern Illinois reported soybean yiel losses ranging from 5 to 48 percent eve though no injury symptoms were observe on the plants. They used SO_2 in their ex periments, but because these were fiel studies, the participation of other unknow airborne substances could not be ruled ou The yield reductions stemmed mainly fror lower seed weights and fewer seeds pe plant.

Botanist Endress and his colleagues ar initiating their studies in an attempt t verify the observations of the Argonn group. They are also concerned wit altered seed quality, which may restrict th dietary or industrial use of soybeans, an air pollutant stress, which may reduce soy bean plant vigor, rendering them mor susceptible to pathogens.

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NATURAL HISTORY
SURVEY REPORTS

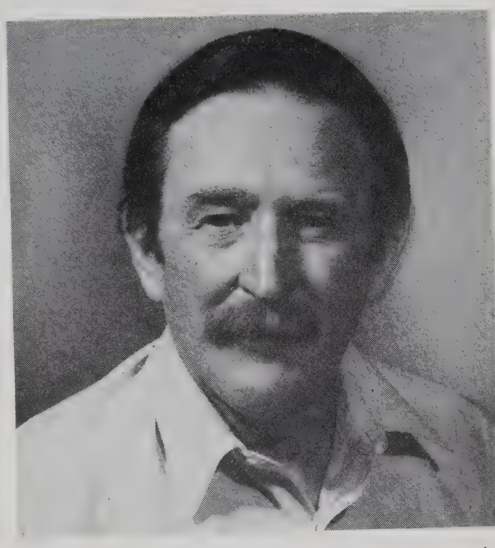
JUNE 1981, NO. 20[illegible]

omer's Odyssey to China

Homer Buck, Survey aquatic biologist, ecently returned from the People's Reublic of China where he served as an inited consultant for the development of xpanding aquaculture programs. His trip vas sponsored by the Food and Agriculure Organization of the United Nations UNFAO). This article is a summary of is travels and observations.

One of the great challenges of our age is o increase the production of food in Asia, Africa, and other developing areas. The ood most desperately needed by millions of ungry people is animal protein, and one of the most efficient ways to produce the protein is through aquaculture. Of the programs now in operation, or under development, one of the newest and most promising is the Asian Network of Aquaculture Centers.

UNFAO through its United Nations Development Program (UNDP), in concert with various host governments, recently has completed centers in India, Thailand, and the Philippines. These centers have elaborate facilities, and are well funded and well staffed for two principal purposes: (1) to develop and/or improve the technologies that offer greatest potential for the efficient, high-volume production of fishes, prawns, and other forms of aquatic protein: and (2) to train technologists and potential aquaculturists to apply the technologies that are developed. A fourth Asian center, and potentially the most important, is nearing completion at Wuxi (near Shanghai), People's Republic of China. It will be known as the Regional Lead Center for Integrated Fish Farming. Its special importance derives from two auxiliary purposes: (1) the training of technologists from other developing countries and (2) the extension of Chinese technologies on a global basis.



Dr. Homer Buck, Survey Aquatic Biologist (Photo by Les Woodrum, Survey Photographer).

The traditional Chinese system involves an almost total integration of agriculture and aquaculture. For example, in areas where fish production is the primary function, the production goals for all other agriculture commodities are geared to the quota that was established first for fish production; and labor, land, water, and other resources are apportioned accordingly. The Chinese system has manures, vegetable tops, green fodder, etc., all entering fish

ponds in either a fresh, fermented or composted form; and the organically enriched silt is removed annually from the pond bottoms and returned to the land as fertilizer. While this ancient system is unquestionably successful, there has been surprisingly little analysis or documentation of how or why it works, or of which elements of the system are the most important or efficient. It also is recognized that the systems of integration as practiced in China will have to be modified to meet the needs, climate, and resources of other areas.

The Chinese system is not unknown in Illinois. Since 1975 the research program at the INHS field station at Kinmundy has included studies of the application of certain Chinese methods to our midwestern agricultural systems. This has been done because we in time will need to maximize the use of our diminishing resources. As a result of the Kinmundy studies, Buck, of the Kinmundy staff, was invited to China to participate in the development of the program of research for the new Chinese center. Additional members of the task force included (1) a second consultant, Gerald L. Schroeder, who has conducted extensive research in manured fish ponds in Israel; (2) T. V. R. Pillay, Chief Administrator of Aquaculture Development in the Rome headquarters of the UNFAO; and (3) Chen Foo-Yan, Project Coordinator for the UNDP Network of Aquaculture Centers in Asia, headquartered in Bangkok. Following initial briefings and a good measure of hospitality from Chinese officials in Peking, the task force travelled by train approximately 1,000 km south of the site of the new center at Wuxi to meet with Chinese counterparts. A second flurry of briefings and festivities was followed by nine consecutive, very intensive days of discussions, writing, and translation, followed by more discussions, writing, etc., broken only by a one-day excursion to two local communes. The meetings were extremely cordial and stimulating.

The final product was a documentary draft outlining 16 specific areas of research to be addressed over an initial 7-year period. Five of the 16 specific points of investigation are listed as examples.

1. Comparative studies on the effects of fresh and fermented animal manure on fish yields.
2. Comparative studies on the performance of different livestock manures in relation to fish production.
3. Studies on the relative values of green manure and animal manure on fish production.
4. Water quality and pond dynamics studies for establishing an upper limit of manure quantum which could be "safely" added to fish ponds under different environmental conditions.
5. Comparative studies on the economics of dual and multiple integration of crops aimed at establishing models for various integrated farming systems.

It is believed that critical examination of the Chinese systems and procedures will yield short-term benefits to China and to other developing countries, and will in time prove useful in Illinois.

Putting the Heat on Horseradish Disease

Illinois, well noted for its soybean and corn production, is the leader in yet another agricultural crop — horseradish. This crucifer, grown for its fleshy pungent roots ground for use as a condiment, is produced on about 1,000 acres in Madison and St. Clair counties near East St. Louis, an area which provides half to two-thirds of the nation's harvest.

Since the mid-1930's Illinois horseradish periodically has been devastated by outbreaks of brittleroot, a condition resulting in yellowing of the foliage, stunting, occasional wilting, reduction in the number of branch roots, discoloration of the root phloem, brittleness of the root, and plant death or severe reduction in quality of harvested roots. Whether the condition was a result of infection by plant pathogenic organisms, mineral imbalance in the soil, or adverse environmental conditions previously was not known.

After a brittleroot epidemic destroyed 60 percent of the Illinois crop in 1979, an in-

Patch of brittleroot-affected horseradish (pale, center plants) (Photo by Survey Entomologist Dan Sherrod).

rdisciplinary team of researchers was put ogether by W. H. Luckmann of the Ecoomic Entomology Section of the Illinois Iatural History Survey and R. E. Ford of he University of Illinois, Department of Plant Pathology. With support from the llinois Agricultural Experiment Station nd the State of Illinois, this team set out o determine the causal agent(s) of brittleoot and its epidemiology. Natural History Survey and University of Illinois entomolo-gists Jerry Schultz, Cathy Eastman, Mickey McGuire, and Karen O'Hayer joined plant pathologists Jacque Fletcher, Robert Goodnan, and Kathy Franklin in this pursuit. Additional expertise was provided by conultants in plant pathology, horticulture, and agronomy at the University of Illinois and by research cooperators at the USDA Plant Virology Laboratory in Beltsville, MD, the Division of Biological Sciences at the University of California at Davis, and the USDA Agricultural Research Station in Salinas, CA.

Although soil fertility and environmental conditions were possible factors in the development of brittleroot outbreaks, the working hypothesis receiving the most support was that brittleroot was a result of the infection of previously healthy horseradish with one or more insect-transmitted pathogenic organisms. Since brittleroot epidemics have occurred at highly irregular intervals, some means had to be found to produce a dependable supply of plants with fresh infections as a source of experimental material. Numerous attempts were made early in the project to produce brittleroot-like symptoms in healthy horseradish by confining these test plants with selected leafhopper and aphid species which had fed previously on diseased horseradish collected from the field during the 1979 outbreak. In two instances brittleroot-like symptoms were produced in test plants, but evaluation of these results was hampered by lack of a critical means of determining differences in the organisms present in test versus control plants.

A major breakthrough occurred in 1980 with the report from research cooperators at the University of California-Davis that bacteria-like organisms had been seen with the electron microscope in thin-section samples from a diseased horseradish plant obtained from Illinois but were not present in samples from a healthy plant. With this lead and with the help of plant pathologists at Beltsville, MD, researchers here were able to culture a small helical bacterium called a spiroplasma and determine that it is **Spiroplasma citri,** known to cause a serious disease of citrus in California and Arizona. This was indeed a surprise because it was the first documented report of the existence of **S. citri** in the U.S. east of Arizona. Subsequently the spiroplasma was isolated and cultured from numerous diseased horseradish plants collected from the 1980 Illinois horseradish crop but was never present in healthy horseradish plant samples.

Armed at last with a reliable method for evaluating laboratory experiments, the research team was then able to test the hypothesis that **S. citri** was the primary

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cause of brittleroot. Plant pathogenic spiroplasmas are known to be transmitted primarily by leafhoppers. The beet leafhopper (**Circulifer tenellus**) was chosen as a test vector because this desert-loving insect is known to transmit **S. citri** to citrus in California and has been collected in Illinois horseradish during some past brittleroot epidemics. These leafhoppers were microinjected with small hand-drawn glass needles containing cultured preparations of **S. citri** previously isolated from diseased horseradish. After the insects were allowed to feed on healthy horseradish some of these horseradish test plants developed brittleroot-like symptoms. **S. citri** was reisolated from the test plants and was not present in control plants, which remained symptomless. In separate tests beet leafhoppers were able to acquire **S. citri** naturally by feeding on diseased horseradish and to transmit the spiroplasma to healthy test horseradish, which then developed brittleroot-like symptoms.

The finding of an association between this spiroplasma and brittleroot of horseradish is only the second instance in which an important plant disease of unknown etiology has been shown to be caused by **S. citri.** Horseradish is also a new addition to the list of reported hosts for this organism.

Work is underway to develop a control program for brittleroot. Other pathogens, especially viruses, known to occur with varying frequency in Illinois horseradish are being checked to determine if they help or hinder subsequent infection of horseradish with the spiroplasma. Selected plant species reported to be susceptible to California-Arizona isolates of **S. citri** are being tested for their susceptibility to isolates from Illinois horseradish to see if they are similar in pathogenicity; to date the team has succeeded in producing infections in periwinkle, turnip, radish, and aster. Weeds, especially crucifers, common in the horseradish production area are also being examined to determine their susceptibility to **S. citri** and, thus, their potential role in brittleroot epidemics. Presently wild mustard, shepherd's purse, and yellow rocket have been infected experimentally with **S. citri.** Although Illinois researchers have shown the beet leafhopper to transmit the spiroplasm to horseradish under experimental conditions, the field vectors for brittleroot outbreaks have not yet been determined; therefore, other leafhopper species common in Illinois horseradish fields are being examined as well for their ability to transmit **S. citri.** Research is being done on how quickly and efficiently the beet leafhopper can transmit the spiroplasma. This information will be important in determining if insecticides will be sufficient to control the leafhoppers and, thus, brittleroot outbreaks.

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NATURAL HISTORY SURVEY REPORTS

SEPTEMBER 1981, NO. 209

ir Traffic Control for Soybean Aphids

Air traffic controllers have been much in ıe news recently, but did you know that it ıay be possible to use a form of air traffic ɔntrol of flying aphids to help reduce the ɔread of soybean mosaic virus?

It is known that soybean mosaic virus is ɔread within fields by flying aphids. Con- ɛquently, a potential means of reducing ıe spread of this disease is to modify the ınding behavior of the disease-carrying phids — to make a field unattractive to phids so that they will not land in it.

Survey economic entomologists Susan Halbert and Michael Irwin knew that ear- ier researchers had obtained contradictory ınd inconclusive evidence as to whether lifferences in the percentage of ground cover influenced aphid landing behavior. They decided to determine the differences n the numbers and species of aphids that are likely to land in soybean fields planted n narrow or wide rows.

The entomologists placed 10 sticky traps designed to catch insects in each of two soybean fields. The distance between rows in one field was 7 inches and in the other it was 30 inches. The experiment was conducted for two growing seasons at the Vegetable Crops Experimental Farm of the University of Illinois. Aphid trapping began on June 11 of the first year and on June 27 in the second year. The leaf canopy of the narrow-row field was closed after the second week of sampling in both years, and during the entire experiment the narrow planting had a higher percentage of ground cover than had the wide one. Aphid trapping was stopped when the canopy closed over the wide-row field, after 35 days in the first year and after 32 days in the second.

The sticky traps were ermine-lime colored ceramic tiles. The color was designed to approximate the color of soybean foliage that is attractive to aphids. The tiles were mounted on ring stands that were, in turn, mounted on steel rods driven into the soil. As the soybeans grew, the tiles were raised and were continually maintained at canopy level.

The entomologists found no statistically significant difference in the total numbers of aphids trapped in the two fields. However, the flying aphids *Aphis citricola* and *Myzocallis punctatus* were caught in significantly greater numbers on traps in the narrow-row field. The species *Capitophorus elaeagni* was collected more abundantly on traps in the wide-row field during the first 2 weeks of the season. That trend was apparent during the remainder of the season, but the difference was not statistically significant; the difference for season totals, however, was highly significant. *Lipaphis erysimi, Rhopalosiphum maidis,* and *Schizaphis graminum,* the three additional species collected in large enough numbers for statistical analysis, exhibited no preferences between the open and closed canopies of wide and narrow plantings.

Of the three aphid species that showed significant preferences, *C. elaeagni* and *A. citricola* have been found capable of transmitting soybean mosaic virus.

The preference for an open or closed

canopy seems to vary among species. Therefore, the possibility of restricting the spread of soybean mosaic virus by adjusting row spacing depends on which species of aphids are locally important.

Of the aphids that responded to ground cover variation, *A. citricola* was collected in greater numbers over continuous cover during weeks 3–5, while *C. elaeagni* was collected in greater numbers over wide rows during weeks 1–2 (and probably during weeks 3–5). Thus, response by flying aphids to ground cover depends on species and time of year. Seed transmission of soybean mosaic virus, one of the most important economic aspects of the disease, is more likely if parent plants are infected early in the growing season. This fact focuses attention on the importance of early season disease-carrying aphids. The early part of the season is also the time when row spacing has the greatest effect on ground cover. Row spacing might be used as a means of limiting the spread of soybean mosaic virus that results in seed transmission if the principal spring and early summer aphids were responsive to ground cover variation.

The entomologists point out that there is no evidence to indicate that manipulation of the percentage of ground cover would eliminate aphid landings and therefore eliminate the spread of soybean mosaic virus. However, depending upon the aphid species involved, it could reduce aphid landings enough to make the practice useful as part of an integrated pest management program to control soybean mosaic virus.

Choosing the Transplanting Season

Survey plant pathologist E. B. Himelick provides this information about tree and shrub transplanting in various seasons (taken from a manual recently published by the International Society of Aboriculture).

The time of year in which transplanting must occur is not always in the control of the planter. Economic or weather conditions may determine a plant's availability. Landscaping may be required immediately upon completion of building construction. Unavailable equipment or labor may delay the planting program. Fortunately, experienced plantsmen using properly prepared plants can successfully transplant most trees and shrubs in any season. The growing of plants in containers has also helped ease the seasonal requirements for transplanting. This is especially true when small shrubs and trees are used in the landscape plan.

The opinions of qualified nurserymen and arborists vary concerning the most satisfactory time for transplanting trees and shrubs. Climatic conditions that vary with locality and year will influence both planting time and planting practices. Plant species and method of digging will also influence season for transplanting.

In general, deciduous plants are preferably planted in the fall after leaf drop and before the soil freezes or in early spring before budbreak. Many tree species may be planted in winter when the soil ball is frozen. The frozen ball must be protected to prevent root damage. Some plant species have a limited tolerance to soil temperatures below 25°F. Narrow-leaved evergreens may be planted in the fall or in the spring before the start of new growth. Broadleaved evergreens are usually transplanted in the spring.

Important factors involved in selecting the planting season are: a) soil moisture and temperature, b) exposure, c) the growth stage of plant, d) plant hardiness, and e) the inherent nature of the species.

Fall planting has the advantages of favorable soil temperature, usually adequate moisture, and time for some root regeneration before the following spring. Winter planting in cold climates has few advantages other than what may be termed operative. It takes advantage of the normal slack period of the plantsman and may permit the use of a frozen soil ball, thus requiring less time for balling and burlapping.

Spring planting has the advantage of ample soil moisture and overcomes the possibility that sufficient roots may not become established before freezing weather. Summer planting has the advantages of timeliness and favorable soil temperature, although soil moisture may need to be supplemented through irrigation. Transplant-

'his large tree spade digs a soil ball 7 feet in diameter weighing about 4 tons, and it is capable of transplant-ng trees with trunks 6–8 inches in diameter. (Photo courtesy of Vermeer Manufacturing Co.)

ng should be avoided during spring and ummer periods when there is rapid leaf growth. It is essential to wait until after the early rapid spring growth has slowed before moving trees in full leaf.

A hardening-off period is frequently given plants before moving to the planting site. This consists of holding plants in a cool, moist place for 1 or 2 days. This will aid in successful late spring and summer transplanting. All plants transplanted in leaf should be moved with a ball of soil. Shipment of plants during the hot summer for long distances can result in severe plant injury. Transplanting operations during the summer should be carried out by experienced arborists, nurserymen, or landscape contractors who will guarantee plant survival.

The History of Illinois Valley Lakes

Several studies have been undertaken recently by the Natural History Survey for the Chicago District, U.S. Army Corps of Engineers. These studies have concerned the effect of the Illinois River's 9-foot waterway on fish and wildlife and the potential effect of a projected increase in water diverted from Lake Michigan. A spin-off of these contract studies was the collection of data on physical parameters of bottomland lakes that relate to their history and to their future for fish and wildlife.

The Illinois Valley has been famous for its waterfowl hunting as far back as the 1880's. During the early 1900's, its commercial fish yield was the largest of any river except the Columbia. The favorable habitat for fish and wildlife was created primarily by bottomland lakes that are associated with the narrow, straight river channel.

The bottomland lakes have undergone many changes since 1900. Wildlife specialists Frank C. Bellrose, Stephen P. Havera, and H. Kathleen Archer are preparing a report about these changes. The first major

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change occurred in the early 1900's as river levels rose as the result of water diverted from Lake Michigan. The increased water levels resulted in a doubling of the surface area of lakes associated with the Illinois River. Under pristine conditions, there were 33,936 acres of surface area in bottomland lakes; this area increased to 67,693 acres as a result of diverted water.

Prior to this diversion, only four lakes were over 1,600 acres, mostly in the valley above Beardstown. The surface area of many bottomland sloughs, ponds, and lakes coalesced to form larger areas. Currently, even with drainage and levee districts eliminating about half of the bottomland lakes, there are 11 lakes of over 1,600 acres.

Shortly after the diversion increased lake areas, drainage and levee districts began to whittle away at the area of bottomland lakes in the Illinois Valley. Before the levee-district era ended in the early 1920's, 184,742 acres of bottomland had been enclosed by levees, eliminating a calculated 21,725 acres of water surface.

As demonstrated by studies made by the Natural History Survey and by the State Water Survey, sedimentation of the remaining water areas in the Illinois Valley provides the gravest threat to their existence. A Natural History Survey Bulletin reported on the sedimentation rate for a number of bottomland lakes (INHS Bulletin 32[1]) in the Illinois Valley. Since then additional studies of sedimentation rates have been made. These studies include Clear, Big, Matanzas, and Grand Island lakes in the La Grange Navigation Pool and Swan Lake (near Grafton) in the Alton Navigation Pool. The later findings on sedimentation rates substantiate those made earlier.

In the earlier report it was pointed out that sedimentation rates varied linearly with water depth, the deep areas filling much more rapidly than shallow ones. As a consequence, the basins of most bottomland lakes are saucer shaped and shallow. The mean water depth of all sampled lakes was 2 feet. Upper Peoria Lake is the deepest, with a mean depth of 3.2 feet.

At the 1-meter (1.1 yards) water depth bottomland lakes are filling with sediment at rates that vary from 0.5 to 1 cm (0.2 to 0.4 inch) per year. Upper Peoria Lake is filling with sediments at a faster rate than any other lake — nearly 2 cm (0.8 inch) per year. The projected half-life of Illinois Valley lakes is quite short — 24–230 years. By the time the half-life is reached, those lakes will be too shallow to provide sufficient water for fishing and boating and will provide for only limited waterfowl hunting.

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ATURAL HISTORY
SURVEY REPORTS

OCTOBER 1981, NO. 210

ew Pine Disease

My pine trees are dying. Today this is common statement made by many Illi- ɔis homemakers, foresters, nurserymen, ıd Christmas tree growers. Dead pine ees are evident along highway plantings, ırks, home landscapes, and commercial lantations throughout the Midwest. A ven pine tree may appear healthy but x weeks later the entire tree may turn rown and die. The pinewood nematode, *ursaphelenchus xylophilus,* and an associ- ted blue stain fungus, *Ceratocystis* sp., ppear to be the causal agents in the pine eaths. Scotch and Austrian pines are the ıost susceptible in Illinois, but it has been ecorded from red, jack, Virginia, and vhite pine.

The pinewood nematode was discovered n Japan in 1913. Currently the nematode s occurring in epidemic proportions in apan, where it has infested 1,250,000 ıcres of pines. The first United States dis- covery of the nematode in Scotch pine oc- curred in 1979 in Missouri. There have

Scotch pine tree killed by pinewood nematode-blue stain fungus disease. All needles on this tree were brown. Note needle loss on lower half of the tree (Photo by J. E. Appleby).

Monochamus carolinensis, vector of the pinewood nematode, feeding on a pine tree (Photo by J. E. Appleby).

been confirmed reports of the nematode in 38 Illinois counties.

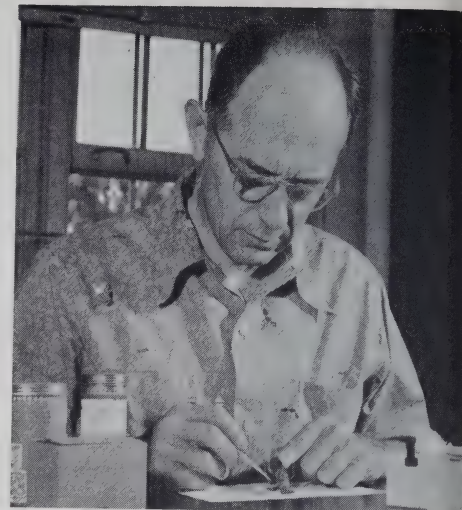
Japanese scientists have reported that the nematode is transferred from tree to tree by several species of longhorned beetles. When nematode-carrying beetles feed on healthy pine trees, the nematodes leave the beetles' bodies and enter the trees through the feeding wounds. Once a tree is infected the nematodes increase in numbers at an alarming rate. The tree can be infected in early summer and be dead three months later.

The longhorned beetle, *Monochamus carolinensis,* is a common pine borer found in Illinois and is a pinewood nematode vector. The adult beetle measures 20-25 mm in length. Within the breathing pores (spiracles) of a single adult beetle, thousands of nematodes have been found. The female beetles deposit their eggs on a dead or dying pine tree that may be in such condition because of the nematode infestation. After the beetle eggs hatch the wood-boring larvae within the pine trees become infected with the nematodes if they are present. The following year when the adult beetles emerge during late spring and summer, they may act as vectors of the nematodes to previously healthy trees.

Is it the nematode or the fungus that is the primary cause of pine tree death? Is it a combination of both organisms? To address the problem, a multidisciplinary research team from the Natural History Survey and the University of Illinois has been formed. The members are J. E. Appleby, J. K. Bouseman, T. W. Curtain, E. B. Himelick, J. J. Jokela, R. B. Malek, M. M. Meyer, R. Randell, F. A. Giles, and D. J. Williams. The team will work to solve many of the unknowns about the nematode-fungus-beetle-pine relationships. It is hoped that the research efforts will find a means of preventing the loss of pines within Illinois.

Herbert H. Ross to Receive Founders Memorial Award of ESA

Dr. Herbert H. Ross has been selected posthumously to receive the Entomological Society of America's Founders Memorial Award. Dr. Ross, former Assistant Chief,



Herbert H. Ross, distinguished entomologist.

Principal Scientist and Section He (Faunistic Surveys and Insect Identific tion) of the Illinois Natural History Su vey, and Professor of Entomology at t University of Illinois, retired in 1969.

The award will be presented at the a nual meeting of the Entomological Socie of America (ESA) in San Diego, Cal fornia in late November 1981. The awa consists of two parts: the Honoree (a fo mer ESA member) and the Lecturer (current member) Dr. Charles D. Michne Watkins Professor of Entomology at t University of Kansas and member of t National Academy of Sciences, will r ceive the Lecturer part of the award. T Founders Memorial Award, establishe by the Governing Board of the Societ has been awarded annually to honor th memory of a distinguished North America entomologist. Dr. Ross is the only ento mologist in the history of the ESA to b recipient of both the Lecturer (1970) an Honoree parts of the award.

A highly respected scientist, Dr. Ro published 220 scientific works, including books and chapters in 6 other books. Th fourth edition of his popular *Textbook o Entomology* will be published in the ver near future. He was active in several sci entific organizations and served as presi dent of the Entomological Society o America (1954-55), the Society for th

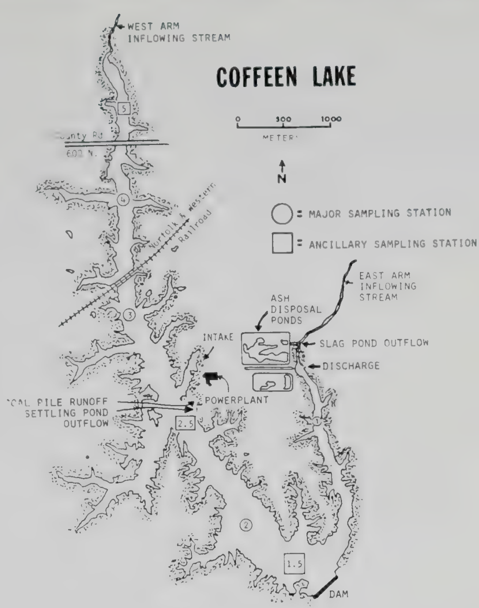
Study of Evolution (1966-67), and the Society of Systematic Zoology (1973-74). Dr. Ross influenced the direction of evolutionary biology and systematics. His evolutionary emphasis helped to evaluate systematics to its present position as a progressive, analytical and synthetic science.

In order to further honor Dr. Ross and to encourage research in systematic entomology, a memorial fund has been established jointly by the Illinois Natural History Survey and Department of Entomology at the University of Illinois. Contributions may be made to the Herbert H. Ross Memorial Fund, University of Illinois Foundation, 224 Illini Union, 1401 W. Green St., Urbana, Illinois 61801.

Trace Metals in Coffeen Lake

The Survey's trace metal laboratory is participating in a multidisciplinary three-year study of the cooling lake (Coffeen Lake, Montgomery County) associated with Central Illinois Public Service Company's Coffeen generating station. In addition to serving as a cooling reservoir for thermal effluent from the coal-fired plant, the lake has, in the past, been used for the disposal of local sewage, mine drainage, and runoff from the coal waste storage areas. Recent improvements in the disposal of coal combustion wastes at the plant have eliminated some of the sources of pollution and should contribute to an improvement in the environmental quality of the lake's ecosystem.

Samples of water, sediment, macrophytes and three species of fish (black bullheads, gizzard shad and largemouth bass) were collected from four established stations representing various thermal regimes and were analyzed for their content of 18 chemical constituents by former Survey analytical chemist Kenneth E. Smith and his associates. During the first two years of the study, the constituents in the collected samples were more concentrated in the first half of the cooling loop of the lake, the area that formerly received discharges from the slag and fly ash ponds, than elsewhere in the lake. In addition, the chemical constituents in all samples tended to decrease in concentration from



Map of Coffeen Lake showing sampling stations of trace metals.

the first year of study to the second year, the time period when improvements in disposal of coal combustion wastes at the plant were implemented.

The mean concentrations of mercury in water exceeded the maximum safe tolerance level for freshwater aquatic life (0.05 ppb, as determined by the U.S. Environmental Protection Agency) in eight of the ten months during the first year of study and in six of the nine months during the second year. However, there was at least a six-fold decrease in average mercury content during the second year. Analysis of water samples collected during the third year of the study is in progress. Preliminary results indicate that the levels of mercury and many of the other chemical constituents continued to decrease during the third year.

There has been concern about the reported reproductive failure in fish inhabiting lakes contaminated with selenium. The levels of selenium in gizzard shad and largemouth bass from Coffeen Lake did not change appreciably during the three-year study (averages of 1.27 ppm and 1.72 ppm, respectively). Black bullheads contained very low selenium levels (average of 0.35 ppm). Third-year levels in carp,

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bluegills and channel catfish were 1.17, 1.19 and 0.80 ppm, respectively. These levels are well within the range of concentrations (0.5-7.0 ppm) reported for fish from other lakes where fish reproduction is normal. Thus the reproductive success of fish in Coffeen Lake should not be affected by selenium at the present.

In order to detect any increased concentration of particular chemical constituents leaving the plant, a mass balance determination of constituents entering (via coal) and exiting (via slag and fly ash) has been initiated. Core samples taken at six transects of the lake during the third year of study are being analyzed by analytical chemist Susanne G. Wood and technical assistant Teresa A. Schuller to determine the concentrations of chemica constituents in the original soil and in th various layers of sediment laid down during the 14-year lifetime of the lake.

Analyses of sediment and macrophyt samples collected during the third year o the study are in progress. Preliminary results indicate a continued decrease in concentrations of the 18 chemical constituents thus reflecting continued improvement o the environmental quality of Coffeen Lake's aquatic ecosystem.

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SURVEY REPORTS

NOVEMBER 1981, NO. 211

ooling Lake Study Published

Reservoirs constructed specifically for e dissipation of waste heat from industry nstitute a relatively new aquatic environ-ent that presents both problems and tractive potentials. The most apparent ıvironmental problems are those associ-ed with waste heat from a production ocess; the most obvious benefits are recre-ional, especially the unique opportunity r open-water fishing in a northern cli-ıate during winter. To evaluate the detri-ıents and benefits of a cooling-lake eco-stem, one must consider the physical ttributes of the man-made system before ttempting to understand the more com-lex biological relations. Those relationships include the entire food chain of the aquatic ecosystem.

Lake Sangchris, in central Illinois, provides cooling water for the Kincaid Generating Station, a coal-fired electric generating plant that was developed by Commonwealth Edison Company of Chicago in the early 1960's.

Under contract with Commonwealth Edison Company, the Illinois Natural History Survey studied this cooling-lake ecosystem intensively from August 1973 through August 1977 to determine the effects of the thermal discharge and combustion byproducts on the local environment. Investigations included detailed studies of water quality, plankton (minute,

Boat equipped with echo-sounding and remote temperature sensing units for determining fish distributions with respect to depth and temperature in Lake Sangchris.

Researchers collecting fish with an alternating-current electro fishing unit in Lake Sangchris.

floating or weakly swimming plants and animals), aquatic macrophytes (plants), clams, benthos (bottom-dwelling organisms), fish, fish harvest, waterfowl, trace metals, and pesticides. Some studies (water quality, benthos, clams, and aquatic macrophytes) were terminated in 1976, and others were initiated to consider the distribution of larval fishes in the water-cooling-loop portion of the lake and the effect of the impingement and entrainment of fish in the water-intake system of the power plant.

The investigative work was carried out by an interdisciplinary team of specialists. Scientists from the Sections of Aquatic Biology, Faunistic Surveys and Insect Identification, and Wildlife Research participated in the study. The administration and overall coordination of the project were handled at the Illinois Natural History Survey headquarters in Champaign, while field activities were coordinated through a field station at Kincaid, a few miles from the lake. Most of the fishery biologists were based at the field station; other team members were based in Champaign, where more extensive laboratory and analytical facilities were available.

In general, the scientists found that the power plant and the heated water discharged from it created few problems for the animal and plant life of the lake and tl surrounding area. On the other han the heated water flowing into the lake pr vided some benefits, such as a longer grov ing season for largemouth bass and f some forms of plankton.

The strength of the Lake Sangchris ca history lies in the intensive sampling pr gram simultaneously carried out over a year period by a team of investigators a proaching the problems of ecosystems l looking at all trophic levels. The results this intensive study have been published the Illinois Natural History Survey Bulleti as volume 32, article 4, *The Lake Sangchr Study: Case History of an Illinois Coolin Lake.*

Radar Sheds Light on Bird Migration

Everyone is familiar with the sight flocks of birds migrating during the da either tightly clustered or in a V or echelo formation. Even at night, waterfowl ar often heard calling to one another as the make their way across Illinois to the ne stopover. However, the vast majority birds neither fly during the daytime nc call regularly as they migrate — most fl catchers, thrushes, warblers, and sparrov fly silently or call only occasionally, an they fly at night. Do these smaller birds fl

n flocks, or do they make their way alone? Observations with spotlights or observations of birds' silhouettes as they fly across the face of the moon reveal that there are no tight flocks of small birds at night. Often the birds seem to fly alone; sometimes they appear to cluster in aggregations too loose to be directly seen by these visual techniques.

Taking up the question at this point, Ronald Larkin of the Wildlife Research Section has investigated the spatial arrangement of small birds at night using a special radar technique that he developed to record the passage of migrants overhead. The radar, in conjunction with a minicomputer, operates as a bird-counting machine, registering the position in space, time of occurrence, and apparent size of each bird passing through the radar beam. As he reported at a recent International Symposium on Avian Navigation in Pisa, Italy, Larkin obtained good evidence that birds sometimes do, indeed, form loose clusters at night. The distance between a bird and its nearest neighbor in one of these clusters was found to be in the region of 50–100 meters. Quantitative comparisons with computer-generated patterns of "bird" positions (random distributions from a so-called Monte Carlo method) showed that chance events could not have generated the observed patterns.

The loose clusters of birds pose a peculiar problem: If they really represent flocks, how do the birds stay together? It is not likely that the remainder of the "flock" is easily seen by a bird flying several hundred meters above the ground at night, and few species vocalize enough at night to allow auditory communication among flock members. To shed light on this problem, Larkin hypothesized that small birds do not commonly fly in flocks at night, but rather that some agent in the atmosphere causes the birds to aggregate without actual communication. The distinction is often important in field observations: birds congregated around a bird feeder are attracted to a feature of their environment, and the birds may or may not be a social unit.

Atmospheric motion was hypothesized to be the agent causing the birds to form clusters as they fly, not the general wind patterns aloft but the smaller details of the air motion. These small-scale motions (having dimensions of a few hundred meters to a kilometer or two) have been intensively studied by atmospheric scientists in the last 10 years or so; they are important in smog dispersal, in turbulence which imperils aircraft, and in generating the forces which drive storms and other large-scale disturbances.

Examination of the paths taken by weather balloons released at the radar site, just before or just after the clumping of birds was documented, revealed that when the birds were clumped, wind speeds or directions were different at different altitudes. This phenomenon is called wind shear. In one case, no wind shear was found and birds were not clumped. Wind shear almost always generates small-scale waves of the same general kind as those which a breeze generates as it blows across the surface of calm water. Therefore, at least until more definitive data are taken, we can imagine that birds flying at night are acted upon by subtle motions in the atmosphere, resulting in the clumping of birds in loose aggregations. Birds might preferentially fly in certain regions of air to save energy or to obtain navigational information. Or atmospheric motion may simply bunch the birds like flotsam on the sea.

Air-Borne Pollutant Affects Soybeans

Sulfur dioxide (SO_2) is a gaseous discharge from industrial and power plants, and at times, its concentration in the air can be high enough to produce poisonous effects on plants. At a high enough concentration, SO_2 causes a water-soaking appearance as well as interveinal chlorosis in plant leaves. At the cellular level, SO_2 affects a number of events, including transpiration, respiration, and photosynthesis. The exact sequence of events is unclear, but SO_2 does interfere with the structure and permeability of cellular membranes, and it has been suggested that SO_2 affects the lipid component of membranes. However, studies to demonstrate the SO_2 effect on lipid metabolism are few.

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Research scientists in the Section of Botany and Plant Pathology, in cooperation with the Argonne National Laboratory, have undertaken studies to determine what effects, if any, SO_2 might have on the various leaf lipids of soybean plants exposed in open-air fumigation systems. In an open-air fumigation system, which consists of an array of pipes suspended over the crop, the pollutant is released through small openings at controlled rates, and thus the plants are exposed under environmentally realistic conditions. With this system, of course, no comparison is made against plants grown under "clean air."

Sixty-day-old soybean plants exposed to 79 parts per hundred million of SO_2 for 20 days for an average daily period of 5 hours showed a marked change in fatty acids, both as to quantity and composition. The free fatty acids and polar lipids were greatly reduced with SO_2 treatment, while th fatty acid esters increased. A simple overa SO_2-induced shift in lipid metabolism i very unlikely, since the quantitative in crease in fatty acid esters was almost en tirely due to an increase in linoleic acid, highly unsaturated fatty acid, while the de crease in free fatty acids was more genera The degree of unsaturated fatty acids in fluences membrane viscosity and, hence membrane-related processes.

Survey studies have clearly shown a increase in the unsaturated fatty acids wit SO_2 open-air fumigation, and this chang in lipids probably contributes to the in crease in all permeability and to the water soaking appearance of leaves. Thus, w have gained another building block c knowledge about how an air-borne pollut ant affects one of our major agricultura crops.

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NATURAL HISTORY SURVEY REPORTS

DECEMBER 1981, NO. 214

pawning Habits of Darters

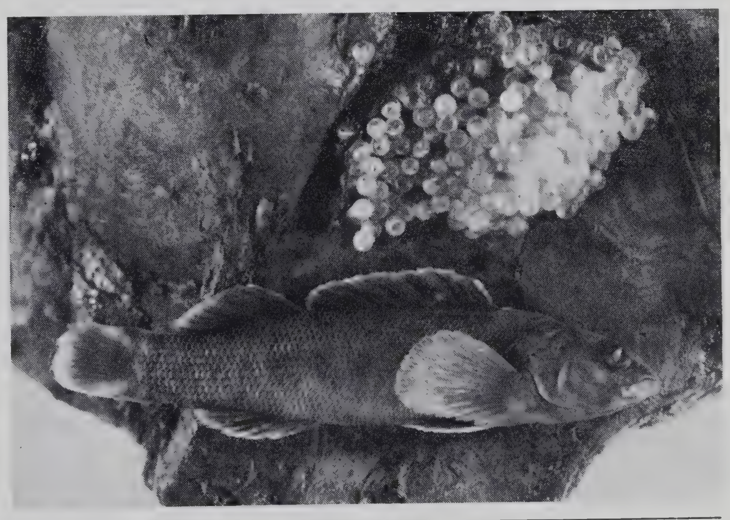
Darters (Family Percidae) are a diverse roup of about 148 species of fishes that re found only in North America. They are econd to minnows (Cyprinidae) in numers of North American species and are xtremely important components of our quatic ecosystems. Twenty-six species ocur or formerly occurred in Illinois.

For short-lived species such as darters, which have a maximum life-span of 1½ to ½ years, the annual breeding season is a ritical period. One or two unsuccessful reeding seasons can eliminate a population. Ecological conditions necessary for uccessful reproduction vary from species to pecies. Information on when, where, and nder what environmental constraints dart-rs lay their eggs is requisite for their rotection and conservation.

Such information is available in the scientific literature on 50 species of darters. During the spring of 1981, Survey ichthyologists L. M. Page and M. E. Retzer obtained data on four more species, the mud, bluntnose, coppercheek, and smallscale darters.

Darters spawn in three general ways: they bury their eggs in the substrate and abandon them, attach them over a relatively large area to objects (usually plants or rocks) above the substrate and abandom them, or cluster them on the underside of an object (rock or log) and guard them until they hatch. Burying eggs is characteristic of primitive species, including all six species of the genus *Percina* for which data are available, and of some species of the genus *Etheostoma*. Attaching and clustering eggs, derived behaviors, are known only in *Etheostoma* but have arisen independently in several subgenera.

The subgenus *Nothonotus* is the only group of darters in which some species bury their eggs and others cluster them. In 1939 in Pennsylvania, eggs of the spotted darters, a species of *Nothonotus,* were found clustered on the undersides of stones held as territories by males. From 1939 to 1981, no other species of *Nothonotus* was



Male, smallscale darter and cluster of eggs on overturned rock (Photo by Les Woodrum, Survey photographer).

reported to cluster its eggs. In May 1981 the Survey ichthyologists found four clusters of eggs of the coppercheek darter in a large rubble riffle in the Buffalo River in Tennessee. Eggs were difficult to find in the swift water, and it was especially difficult to capture a male guarding a cluster of eggs. However, one male was captured beneath a stone with a cluster of eggs attached. To confirm the egg-clustering habit of the coppercheek darter, two males and four females were returned to the Survey and placed in an aquarium outfitted with a current pump and two stones as potential clustering sites. Within three days, one male had established a territory under a stone and was guarding three small clusters of eggs.

Also in May 1981, in a fast riffle in Stones River, Tennessee, a cluster of eggs and an attendant male smallscale darter, another member of the subgenus *Nothonotus,* were found. The cluster contained about 346 eggs and was essentially identical to those of the spotted and coppercheek darters. The smallscale darter is a rare species, existing only in a few widely separated rivers. Protection of the species will require maintenance of these rivers as free-flowing, clean streams with suitable sites for clustering eggs.

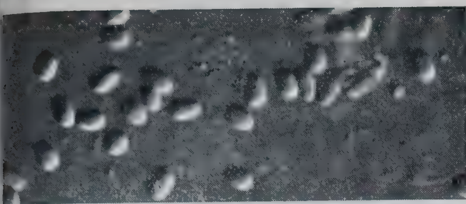
The other two darters studied in 1981 were the mud and bluntnose darters, both common in Illinois. Individuals of eac species were transferred at the peak o their spawning periods to aquaria at th Survey and given a variety of substrat on which to lay their eggs. Followin elaborate courtship behavior, both speci attached their eggs to plant material. A though the habitats (sluggish stream pools of both species suggested plant material a the probable site for egg deposition, tw close relatives of the mud darter, the rai bow and orangethroat darters, bury the eggs in gravel riffles.

Hangingfly Parasites

Mecoptera are medium-sized insects, th adults of which range from ½ to 1 inc in length. The two most common famili of Mecoptera (Panorpidae and Bittacidae occur throughout Illinois and generally a found in moist shady woodlands, especial along streams. Adults of the Panorpid (scorpionflies), represented in Illinois b nine species, generally feed on dead o dying insects. Adults of the Bittacid (hangingflies) are predaceous and han by their forelegs from the foliage of lo shrubs and herbs where they capture variety of small prey, including mosquitoe flies, aphids, and caterpillars. Six speci of hangingflies occur in Illinois.

Little is known about the biology most species of Mecoptera, especially the

Adult hanging fly *Hyalobtacus apicalis* (Photo by former Survey photograph, W. D. Zehr).



pores of a microsporidium from *Hyalobittacus api-alis.* Wet mount photographed with Nomirski inter-erence contrast (800X) (Photo by J. V. Maddox, Sur-ey entomologist).

ıatural enemies. Some of these natural nemies are being investigated by Survey ntomologists J. V. Maddox and D. W. Vebb. They found that entomopathogenic ungi of the order Entomophthorales occa-ionally infect adult Mecoptera but infec-ion rates were less than 5 percent. Neo-gregarine (Phylum Protozoa) infections vere also found in adult Mecoptera but ıgain affected less than 5 percent of the otal mecopteran population.

By far the most common pathogens und in Mecoptera were obligate parasites of the Phylum Microspora (recently moved rom the Phylum Protozoa). Adults of the ıangingfly, *Hyalobittacus apicalis,* fre-quently were infected with a yet unde-cribed microsporidium. Infections were videspread throughout the range of *H. ıpicalis* in Illinois and have been observed every year since 1971. In one study area, rom which *H. apicalis* adults were col-ected weekly, the infection rate steadily ncreased from 5 percent in mid-May, vhen *H. apicalis* adults first start emerging, to 90 percent in late July, just before *H. apicalis* populations disappeared. Fat body and midgut tissues of *H. apicalis* adults were infected by this microsporidium and heavily infected adults soon died from the infection.

Microsporidia are normally transmitted from host to host by a resistant spore and in addition they may be transmitted through the egg from an infected female to her progeny. At this time, we do not know how the infection increases in *H. apicalis* throughout the season or whether the disease is transmitted through the egg to larval offspring.

The microsporidium from *H. apicalis* as well as other microsporidia have been found infecting other species of Mecoptera. Some of these microsporidia are being described as new species while studies on their role as mortality factors in mecopteran populations are continuing.

James Cedric Carter, 1905-1981

J. C. Carter, Plant Pathologist and Emeritus Head of the Section of Botany and Plant Pathology at Illinois Natural History Survey and Emeritus Professor of Plant Pathology at the University of Illinois, died September 27, 1981, at the age of 75 years.

He served as an assistant in plant pathology at Purdue University from 1931 to 1934 and as a technical research assistant on fungicide studies at the University of Delaware during the summers of 1931 and 1932. On May 14, 1934, he joined the Section of Applied Botany and Plant Pathology of the Illinois Natural History Survey as an Assistant Botanist. He was appointed Head of the Section of Applied Botany and Plant Pathology on January 1, 1955 and received a joint appointment to the faculty of the University of Illinois as Professor of Plant Pathology that same year.

After 40 years of outstanding service and devotion as a researcher, educator and administrator, he retired on June 1, 1974 and moved to Crawfordsville, Indiana, near the place where he was born. He continued part-time teaching at Wabash College in Crawfordsville during his retirement years.

James Cedric Carter.

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Dr. Carter was an authority on shade and ornamental tree diseases. He worked on numerous diseases of trees and shrubs and was a primary influence in the early development of modern urban arboriculture in the United States. Some of the major tree diseases on which he worked were Verticillium wilt, wetwood of elm, anthracnose of oak and sycamore, elm phloem necrosis, Dutch elm disease, and several canker diseases of trees and shrubs. For over 25 years he was considered the foremost authority in the Midwest in the diagnosis of infectious and noninfectious diseases of trees and shrubs. His extensive knowledge and experience in observing symptoms of diseases, sectioning of fungal fruiting bodies, and identification of cultured organisms from infected plant material made him a highly valued resource person.

He was the author or co-author of over 140 scientific publications. His book *Diseases of Midwest Trees* (first published in an earlier form in 1964 as *Illinois Trees: Their Diseases*), remains an important reference on diagnosing tree diseases. In 1970 he published a companion manual on the selection, planting, and care of trees that is widely used by professional horticulturists and arboriculturists.

Dr. Carter received many awards and honors during his career. Among them were a special award from the National Arborist Association for his research on the wetwood disease of elm; the Outstanding Service and Past Presidents awards from the Midwestern Chapter, International Society of Arboriculture; and the Author's Citation, Past Presidents, and Honorary Life Member awards from the International Society of Arboriculture. He was an honorary member of the Indiana Arborist Association and the Illinois Commercial Arborist Association. For several years he served as chairman of the Illinois Tree Experts Examining Board.

Dr. Carter contributed significantly to the professional field of arboriculture through his personal research and his many years of association with the International Society of Aboriculture. He was a gracious person who freely shared his knowledge, experiences, and inspired his professional associates. His friendly and kindly disposition were his constant personal traits. Dr. Carter is still with us in the form of the personal inspiration he gave to those who worked with him and the many professional contributions he made for the improvement of the urban environment through the protection and maintenance of shade trees.

Dr. Carter married Margaret Lucile (Rogers) Carter, also originally from Indiana, on August 18, 1934. They always graciously loved and cared for each other throughout their 47 years of marriage. He is survived by his wife, one son, two daughters, 10 grandchildren, and three great-grandchildren.

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'heasants Threaten Jasper County 'rairie Chickens

The introduced ring-necked pheasant as replaced the native prairie chicken over nuch of the great plains and eastern tall rass prairie region during the last half entury or so. Most of the shift in numbers nd distribution of the two species resulted rom the conversion of native prairies, and ater of such substitute prairies as hayfields, astures, and grass-seed meadows, to the roduction of corn, soybeans, and small rains. Pheasants are more tolerant of inensive agriculture than are prairie chickns. According to many wildlife professionls and laymen, the loss of the native bird nd the gain of the exotic was purely a natter of habitat change. This contention s not entirely true according to recent evilence gathered by Survey wildlife biolgists Ronald L. Westemeier and John E. 3uhnerkempe.

Once numbering in the millions, prairie hickens in Illinois had been reduced to pproximately 300 birds in the spring of 981. Near Bogota in Jasper County, rairie chickens responded dramatically rom 1968 to 1972 to the development of ,000 acres of nest sanctuaries by increasng their numbers from about 80 to 400 irds. Similarly, 640 acres of sanctuaries vere established near Kinmundy in Maron County through the combined efforts f the Natural History Survey; the Illinois Department of Conservation; the Prairie Chicken Foundation of Illinois (now disanded); and the Illinois Chapter, The Nature Conservancy, plus other agencies nd private conservationists. Curiously, he Kinmundy flock now exceeds the 3ogota flock despite the large difference in anctuary acreage. A critical factor differntiating trends in abundance of prairie chickens on the two areas appears to be the development of a thriving pheasant population over the past 10 years at Bogota, whereas the Kinmundy area has almost no pheasants.

The adverse impact of pheasants on prairie chickens at Bogota may be summarized as follows: (1) Both the population of, and nesting effort by, prairie chickens have become increasingly concentrated on the two central sanctuary units, with the five peripheral sanctuary units largely abandoned or little used. (2) Harassment of courting and mating prairie chickens by pheasants has become relatively common. (3) The nesting effort of prairie chickens (number of nests, but espe-

A female prairie chicken entering her nest.

cially hatches per hen) has been substandard in several springs (i.e., increasing numbers of hens have apparently not nested) since pheasants have become abundant at Bogota. (4) For the prairie chickens that do nest, there is an increasing likelihood of parasitism by pheasants, resulting in desertion, predation, or if hatching occurs, a parasitic pheasant brood and the probable loss of the prairie chicken brood. Twenty-five prairie chicken nests were found that contained eggs from both species; success in hatching was significantly lower for these nests than for prairie chicken nests that contained only prairie chicken eggs. In two cases the pheasant eggs were hatched, but the prairie chicken eggs contained dead but nearly full-term embryos. The incubation period for pheasant eggs is about 2 days shorter than the incubation period for prairie chicken eggs. (5) If parasitism does not occur, the probability of nest abandonment is increased, apparently related to the presence of pheasants. (6) If parasitism and desertion do not occur, increased embryonic mortality currently results in 1-2 fewer than normal prairie chicken chicks hatched per clutch. This fact suggests altered behavior of nesting hens, such as reduced attentiveness during incubation due to harassment of pheasants.

No species can long withstand such adversities as those imposed by pheasants on prairie chickens, when added to more normal problems of predation, weather, and intensive land use. At this point, the survival of prairie chickens in Jasper County must be regarded as uncertain, perhaps doubtful, with pheasants at their present high levels. Should the pheasant become well established on the Marion County prairie chicken sanctuaries — a distinct possibility — the extinction of the prairie chicken in Illinois seems probable. A sustained program of pheasant control is clearly called for, and is being considered, in programs to preserve the Illinois prairie boomer.

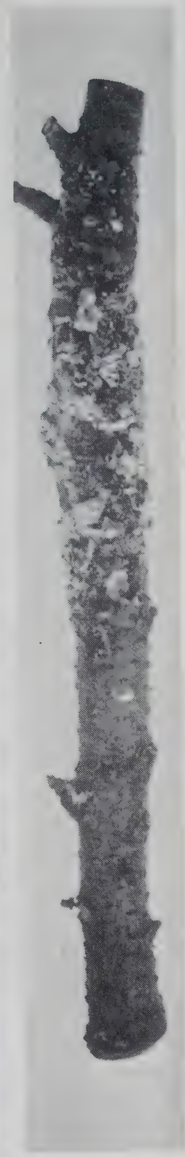
Drought and Spruce Canker

Blue and Norway spruces are highly prized as landscape trees throughout Illinois. Very blue selections of Colorado spruce, called "shiners," and the grafted blue cultivar Koster are some of the most expensive landscape plants available. The retail price of a young blue spruce at the nursery may reach $20 per foot of height. Therefore, disease or insect damage on a blue spruce can be of great concern to the grower and even more so to the homeowner.

Fortunately, spruces grow well in the Midwest, with few insect or disease problems. However, a stem canker disease caused by the fungus *Valsa kunzei* appears to be causing increasing damage on both blue and Norway spruces. Although the disease has been recognized for many years, attempts to cause infection by artificially inoculating vigorous spruce seedlings were unsuccessful. There seemed to be some association between environmental stress and the severity of infection, but research to confirm this association was lacking until recently.

Survey plant pathologist D. F. Schoeneweiss has conducted research on the role of environmental stresses in diseases of woody plants for over a decade. When he inoculated stems of Colorado blue spruce with the canker fungus and subjected the plants to controlled drought stress, typical stem cankers formed, while nonstressed stems remained resistant. The cankers appeared as enlarging areas of dead bark surrounding the inoculation points. Although the fungus was able to survive and grow to some extent in the wood of both stressed and nonstressed stems, injury was confined to the bark tissues of stressed stems. In contrast, most canker fungi attack and kill cells of the water-conducting tissues in the wood, causing wilting and dieback of branches.

The level of water or drought stress imposed on spruces in this study was quite severe, yet stressed plants did not exhibit visible signs of wilting. Needles and twigs of spruce are quite rigid, and it is usually not possible to tell whether a spruce is under water stress by its appearance. Since drought stress may cause spruces to become susceptible to attack by *V. kunzei,* proper maintenance of landscape spruce trees

A Colorado blue spruce from which the lower branches had been removed over a period of several years because of *Valsa* canker infection. Right: A swollen stem canker with the exuding pitch characteristic of the disease.

should include a regular watering schedule, particularly during drought periods.

In his research program on stress and plant disease, Schoeneweiss has shown that other environmental stresses, in particular hard freezes following mild weather in the fall, may cause woody plants to become susceptible to attack by stem canker fungi. Studies are now in progress to determine the possible role of freezing stress in the appearance of *Valsa* canker on spruce.

Experimental Ecological Reserves

The need for preserving natural areas has long been recognized at both national and international levels. Biosphere Reserves are being established at the international level to conserve genetic diversity and encourage environmental research and education. In the United States national wilderness areas and state nature preserves serve as ecological reference points for

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base-line monitoring. Research in such preserves is necessarily observational so that the area can remain as unaltered by man as possible.

The need for other areas where experiments can be performed has been recognized only recently. In 1974 the Federal Committee on Ecological Research recommended Experimental Ecological Reserves "to provide sites for manipulative experiments, management testing, and observations of the results of human impact." The Institute of Ecology, a consortium of private, state, and national institutions dedicated to interinstitutional research and policy analysis in ecology, evaluated potential Experimental Ecological Reserves in the United States, Virgin Islands, and Puerto Rico. In 1975-1976, 67 terrestrial sites were selected, and in 1980-1981, 29 aquatic sites, including one submitted jointly by the Natural History Survey and Western Illinois University. The site is unusual because it consists of three locations on two rivers: the Alice Kibbe Life Science Station of Western Illinois University on Pools 19 and 20 of the Mississippi River, the Survey's River Research Laboratory at Havana located at the midpoint of the Illinois River, and the Survey's other river laboratory at Grafton at the confluence of the Mississippi and Illinois rivers.

These laboratories will provide access to two large alluvial rivers subject to quite different degrees of human impact. The Illinois River has most certainly been the subject of large-scale manipulative experiments although the experiments were not designed by biologists. Observations of the results of human impact, such as the diversion of Chicago sewage into the river starting in 1900, have been made for over 100 years. The Mississippi River has been influenced relatively less by man.

The joint Natural History Survey-Western Illinois University site is the only Experimental Ecological Reserve selected in Illinois and one of only six sites (including terrestrial sites) in the North Central Plains, which includes substantial parts of 12 states. Together with the other 95 sites, the Big River Site should help to achieve the national goal of providing a network of research facilities where the functioning of major ecosystems of the United States can be investigated.

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SURVEY REPORTS

FEBRUARY [illegible] NO. [illegible]

roject Gypsy Moth

A bright, sunny June afternoon with iillions of caterpillars crawling over patio ırniture, sides of homes, and crawling own completely defoliated trees could be typical scene in an Illinois woodland in ıe not too distant future. The gypsy moth ıvasion into Illinois has begun. In 1981 ersonnel of the Illinois Department of ıgriculture captured 2,634 male gypsy ıoths in traps located throughout the tate. The largest number of moths caught vere in the Chicago region. The steadily ıcreasing number of captures during the ast few years indicates that outbreaks of ;ypsy moth caterpillars are imminent.

The gypsy moth overwinters in the egg tage. Masses of eggs containing from 75 o 800 eggs are often found along protected ıreas of the tree trunks, on wooden fence osts, in rocky crevices near the infested rees, on camping trailers and tents, and in ı multitude of other places. Eggs hatch in he spring when the tree leaves are unfolding. The newly hatched caterpillars climb to the treetops and often spin down on silken threads before feeding begins. Wind currents during this period can transport the caterpillars for miles. If windblown caterpillars fall on a suitable host, feeding begins. Gypsy moth larvae feed on many kinds of trees and shrubs but the favorite hosts are oaks. Oak trees which are defoliated for 3 consecutive years often die. The caterpillars feed voraciously on the plant foliage for about 5 weeks. When mature the dark colored caterpillars can be recognized by the 5 pairs of blue and 6 pairs of rust colored dots down the back. With the completion of feeding the larvae wander over tree trunks, the ground, and surrounding structures where they spin cocoons and change into the inactive pupal stage which lasts about 3 weeks. Pupae can be transported great distances if they are attached to automobiles, campers, and railroad cars. It is during years when high populations occur in the eastern states that pupae are often transported into the Midwest. Upon emergence from the pupa, the nearly flightless white female moth produces a powerful odor or pheromone which attracts the male moths. (It is the synthesized pheromone which is used in traps to capture the male moths.) The dark brown male moths mate with the female, and shortly thereafter the female moths deposit the egg clusters. The egg clusters also can be transported great distances by vehicles.

Gypsy moth caterpillar (full grown length ca. 50 mm). (Photo by J. E. Appleby).

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laregmouth bass is integrally involved in determining the thermal tolerance/preference limits of this species. This has tremendous ramifications for fisheries management practices.

Past hatchery procedures have all too often overlooked genetic differences between populations. It is particularly distressing to observe the degree to which "Florida largemouths" are being propagated and widely dispersed in states other than Florida. The viability and reproductive success of these introduced bass in these foreign environments is unknown.

The present demonstration of genetically divergent populations suggests that many states may be wasting valuable resources by attempting to introduce "Florida bass" of questionable genetic composition into their lakes. Once genetic differences between largemouth bass populations are better understood, and once the role that short-term and long-term fitness plays in determining the range and distribution of phenotypes is more fully elucidated, fisheries biologists will be in a better position to design effective management programs.

This study has generated the following recommendations for improving management procedures for largemouth bass:

1. Each state should be responsible for analyzing samples of largemouth bass from a number of lakes and rivers throughout its area to determine the genetic composition of these populations so that baseline data will exist from which sound management plans can be constructed.
2. Each state should determine the genetic composition of samples of all largemouth bass produced in its hatchery system, as well as of samples of all largemouth bass obtained from other sources, to insure genetic compatibility with native stocks.
3. Each state should select hatchery brood stock regularly from wild populations highly representative of the area which that hatchery serves. Several batches may be required to produce several different stocks of largemouth bass, each to be used for different environments or situations.
4. The effectiveness of the stocking program should be evaluated and long-term effects on the genetic composition of specified laregmouth bass populations should be monitored.
5. All precautions should be taken to insure that the genetic integrity of the two subspecies of largemouth bass are protected from uncontrolled promiscuous stocking programs.

The Illinois Department of Conservation in conjunction with the Illinois Natural History Survey is currently practicing these recommended procedures in the design and implementation of the largemouth bass management programs within the State of Illinois, procedures which should result in more efficient and effective management of this important game fish.

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NATURAL HISTORY
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What Are Lichens?

Lichens are mysterious and unusual plants, ccording to Survey mycologist and lichen-logist J. Leland Crane. Part of the mys-ery lies in their very nature. An individual chen is a unique organism composed of microscopic green or blue-green alga and colorless fungus. The alga and fungus ive together in a mutually beneficial asso-iation termed "symbiosis." The plant body hat is formed has no resemblance to either he algal or the fungal component.

The algal partner provides food energy hrough photosynthesis, and the fungal artner lives on this food, makes up the ulk of the lichen body, protects the alga rom dessication, absorbs mineral elements and water, and synthesizes many essential organic compounds.

Lichens are widely distributed and are found on a great variety of substrates, such as rocks, trees, woods, and soil. They are found in the Arctic (where they are dominant in the tundra) and the Antarctic, from sea level to alpine habitats, in deserts, and in freshwater and marine environments. Some lichen communities last for centuries in the Arctic and Antarctic, but if the environment is disturbed, they are eventually replaced by mosses, liverworts, and higher plants.

Lichenology, the study of lichens, still lags behind studies of the higher plants and even of mosses and fungi as a developing science, but this lag means that it is an exciting field where many new discoveries can be made.

Movements of White-tailed Deer

Movements of wild animals have long interested biologists, and a large number

Two species of the lichen genus *Parmelia* attached to rock (left) and to tree branches (right). (Photos by J. Leland Crane)

of studies have included descriptions of animal movements. Many birds are well known for their long-distance flying ability and seasonal migrations of thousands of miles. The movements of mammals are generally less familiar but can be equally remarkable. The caribou, for example, may travel 500–600 miles between its winter and summer ranges.

Research has been done throughout North America on the movements of white-tailed deer. Though not as mobile as the caribou, deer travel greater distances than most people realize. In the more southern states, where seasonal changes in weather are slight, deer move only short distances, usually less than 3 miles. In the north, where weather changes are more extreme, deer migrate between summer areas and winter "yards" or concentration areas, which may be as much as 25 miles apart.

Deer movements in Illinois have been examined in the past by biologists of the Natural History Survey and Southern Illinois University in the more forested southern part of the state. They found that marked deer traveled up to 22 miles from the release site, with yearling bucks going the farthest.

Until recently, very little was known about the movements of deer in the northern, more agricultural areas of the state. Survey biologists C. M. Nixon, Lonnie P. Hansen, and James E. Chelsvig are currently studying the movements of deer at Robert Allerton Park near Monticello in Piatt County. The deer are captured and fitted with radio-transmitter collars or some form of visual identification, such as ear streamers or plastic reflector collars.

About 57 percent of the deer marked during the first 2 years of the study are believed to have left the park. Some deer migrate between their winter range in Allerton Park and their summer range somewhere within 15 miles of the park. Other deer that have left the park but have not returned have been observed at Champaign (27 miles), Lake Shelbyville (33 miles), Chesterville (24 miles), Homer (38 miles), Taylorville (48 miles), Sigel (55 miles), and Morris (91 miles). These results indicate that deer in Illinois

A doe fawn about 8 months old wearing a reflec[t...] collar. (Photographed at Robert Allerton Park [...] James E. Chelsvig)

are not as sedentary as is generally b[e]lieved. Some questions that remain una[n]swered are how many deer move in[to] Allerton Park from other areas, and ho[w] far do they come? Answers to these que[s]tions will have to come from future tra[p]ping and tagging efforts in other areas [of] the state.

Dynamics of Insect Adaptation to Soybeans

Economic entomologist Marcos Koga[n] recently prepared a report showing ho[w] insect pests adapt to soybeans, what kin[ds] of soybean pests may occur in the futur[e] and the long-term concerns of integrate[d] pest management programs for soybeans.

The species composition and structur[e] of arthropods (a phylum that include[s] crustaceans, insects, and spiders) assoc[i]ated with a crop are the result of a highl[y] dynamic adaptive process. The main com[]ponents of this process are the crop wit[h] its complement of production practice[s,] the associated fauna inhabiting or crossin[g] the crop space, and the physical environ[-]

nent in which the crop and the fauna coexist. When a crop plant is introduced into a new region or when the area under cultivation to a crop is expanded, there is a rapid accumulation of arthropod species capable of using the new food resources as they become available. The crop is colonized by numerous arthropod species that may or may not remain associated with it. Certain of these species may, in time, become predominant elements of the fauna and eventually reach pest status.

The development of arthropod communities on soybeans in the western hemisphere has followed such a process of adaptation. The soybean, a plant native to eastern Asia, was introduced into North America in the early 1800's. In 80 percent of the world soybean acreage this crop has been extensively grown for less than 50 years.

As one tries to assess the variation in pest status of arthropod species within regional soybean arthropod communities, four key questions must be addressed. (1) Are all major plant parts, at every growth stage, efficiently exploited by arthropod pests? (2) After the introduction of soybeans into a new region, what have been the major sources of colonizers? (3) What are the sources of potential new colonizers after an initial species equilibrium has been achieved? (4) Can control practices in an integrated pest management program accelerate or delay the adaptive processes that lead to a fuller exploitation of soybean resources by arthropods?

Kogan attempted to answer these questions by comparing soybean arthropod communities in North and South America, regions where the crop has been introduced rather recently, with arthropod communities in east Asia, the probable center of soybean origin.

The answer to the first question (niche occupancy) is that in the Orient there is a rich fauna on soybeans capable of effectively exploiting most identifiable resources. The most serious pests in this region are oligophagous (eating only a few, usually related, plants) and are well adapted to soybeans. In America, however, most major soybean pest species are polyphagous (eating various plants). Furthermore, it seems that several critical niches are unoccupied or incompletely occupied. This is particularly true for pod-boring species in the United States and to some extent also in major growing areas in Brazil.

The second question concerns the sources of colonizers of soybean fields after the plant has been introduced into new areas. When soybeans have been introduced into new regions in North and South America, they usually have replaced other crops or the natural plant cover (meadows or woods). Certain elements of the existing fauna in the region have adjusted to the new crop. These adjustments have been more or less gradual, and in general have included: (1) the expansion of host ranges by polyphagous species to include the soybean in their diets, (2) the gradual adjustment to feeding on the soybean by oligophagous species normally associated with cultivated or wild legumes, and (3) the changing of feeding habits by oligophagous species adapted to feeding on other plants so that they have become capable of eating and developing on soybeans.

The answer to the second question is, therefore, that the soybean arthropod community in North and South America is constituted of elements of the fauna that existed in the area before the introduction of the crop. The occupation of soybean niches occurred rather rapidly, generally resulting in a rich fauna associated with the crop. This fauna, however, is not specialized to soybean feeding, and in most instances, plants preferred for feeding and oviposition are other cultivated legumes or plants of the wild flora. In the Orient, however, certain species are highly adapted to soybean feeding.

The third question refers to the probability of the replacement of existing species by others that may have a competitive advantage for occupation of the same niches. These potential colonizers may result from changes in species of the native fauna or from the immigration of exotic species. Natural mechanisms capable of producing changes in the local fauna are (1) legume-associated oligophagous feed-

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ers becoming better able to exploit soybean resources, (2) greater specialization of polyphagous species with regard to the soybean, (3) shifts in the food range of non-legume-associated oligophagous species, and (4) accidental invasion of the area by exotic species.

Research shows that such shifts in feeding habits have indeed occurred in the past. The fourth and eventually most dangerous source of new colonizers is immigrant species, particularly from countries in which soybeans have been cultivated for a long time. The midwestern states may be particularly vulnerable to this kind of invasion, because species highly adapted to soybeans in the Orient occur in areas of similar latitude and overall ecological conditions. The pod borers are the most serious candidates for movement from the Orient to the Americas, and certain defoliators may represent a potential threat in the opposite direction. Early detection of possible transcontinental shifts is perhaps the only measure to forestall the impact of immigrant species.

The final question, then, is whether certain control practices can accelerate or delay the evolutionary processes that lead to a fuller exploitation of available niches in soybeans. Integrated pest management includes, among other tactics, cultural practices (such as the elimination of preferred plant hosts, the associated crops within the agroecosystem, the presence of alternate hosts as sources of colonizers, row spacing, various tillage practices, the selection of planting dates, and crop rotation), host plant resistance to pests, and chemical controls. Integrated pest management, as a multifaceted approach to the regulation of pest populations, must consider in each case the long-range effects of every control tactic. Since the ecological balance in agricultural communities is extremely delicate, any changes in these practices may bring about serious shifts in the faunal composition. Some of these have been detected in the past, and others may be predicted for the future.

The threat of an evolving, better adapted insect fauna less vulnerable to currently available control tactics must be considered in planning long-term insect pest management systems for soybeans. Monitoring these faunal shifts should be an integral part of research programs in soybean entomology.

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NATURAL HISTORY SURVEY REPORTS

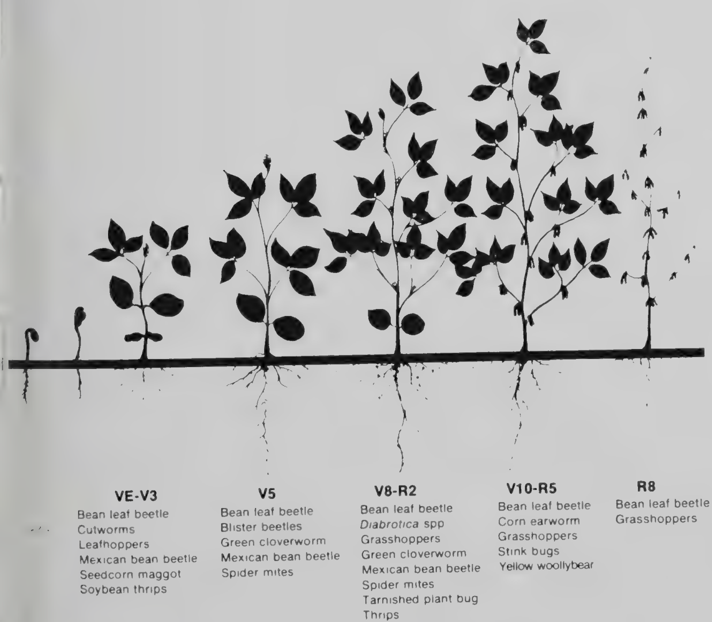
APRIL 1982, NO. 216

lanaging Soybean Insects

A very informative publication, "Soy-ean Insects: Identification and Manage-ıent in Illinois," *University of Illinois Ag-:cultural Experiment Station Bulletin 773* ecently was published by Marcos Kogan nd Donald E. Kuhlman of the Illinois Vatural History and the University of Illi-ıois. This profusely illustrated 58-page ıanual contains economic, ecological, and ntomological guidelines that are intended o optimize effective, insect pest manage-nent practices for soybean production. 'ublication of the bulletin was made pos-ible by a grant from the Illinois Soybean 'rogram Operating Board.

Soybean in Illinois long has been hought to be somewhat free of major in-ect pests. Actually, insects can attack soy-ean through much of the growing season, ınd this crop that has become so important to Illinois' total economy should be monitored for pest insects. Soybean presently constitutes one-third of the state's annual cash farm income. This economic significance has made it important to manage soybean insect pests with greater consideration for the overall soybean insect complex.

"Soybean Insects . . ." is one response to this developing need. For the record, insect pest management programs are not developed hastily because of the complexity of interrelated issues. Kogan and Kuhlman synthesized the results of numerous research programs and experiences to establish their management guidelines applicable to Illinois. The supporting background can be traced to local, state, national, and international programs in which the Survey and the University of Illinois, plus several other institutions, jointly have participated.



Growth stages of a soybean plant with associated insect complexes (VE-V3 = seedling; V5 = early vegetative growth; R2 = full bloom; R5 = beginning seed; R8 = full maturity).

The guidelines established by the authors are aimed at a wide audience: growers, extension advisers, pest consultants, pesticide dealers and applicators, pest scouts, and farm managers. The bulletin's contents cover growth of the soybean, identification and biology of soybean pests, and the procedures for establishing a soybean pest management program. The succinct writing, the informative charts and figures, and the numerous color illustrations lend to a very readable format.

Persons desiring to purchase individual or multiple copies of this new publication may address their inquiries to the University of Illinois, Office of Agricultural Publications, 123 Mumford Hall, 1301 West Gregory Dr., Urbana, IL 61801 or call 217-333-2548.

Long-Term Ecological Research on Major Rivers

A 5-year, 1.3 million dollar grant from the National Science Foundation (NSF) for a Long-Term Ecological Research (LTER) Project has been awarded to Illinois' Natural History Survey, Geological Survey and Water Survey, all divisions of the Department of Energy and Natural Resources, and to Western Illinois University. The project is designed to study the biological processes in large rivers, specifically the Illinois and Mississippi. The study, contingent on the availability of funds and scientific progress, may last as long as 30 years.

Richard Sparks of the Natural History Survey is the principal investigator of the overall project. Other Natural History Survey staff members who will be involved in this new study are Ken Lubinski, Michael Wiley, Robert Costanza, Robert Gorden, and Paul Risser, Chief. They will cooperate with the co-investigators from the other institutions.

The Division of Environmental Biology of NSF began a new emphasis on long-term research in 1980. This was in response to the subtle pressures that human technology is imposing on many populations, plant and animal communities, ecosystems, and on the earth's biochemistry. It is anticipated that long-term ecological research on selected ecosystems will result in understanding them sufficiently to pr dict their responses to disturbances, and t aid in decision making on policy option environmental assessment, resources mar agement studies, and instruction c students.

The LTER Project awarded to th aforementioned institutions is one of onl 11 funded throughout the U.S.A. and i the only one on river systems. The other include temperate forests, grasslands an prairies, a coastal marsh, the Okefenoke Swamp in Georgia, Wisconsin lakes, an the Jornada Desert in New Mexico. Pri mary considerations of NSF in the accept ance of the Illinois interinstitutional pro posal were the willingness of the principa investigators to make long-term commit ments, the continuity of leadership, in stitutional cost sharing, physical facilities site integrity, lack of conflict in site use and long-term agreement with site owners

Survey scientists will begin their investi gation of major river ecosystems at 3 se lected sites: Pool 19 (Keokuk Pool) or the Mississippi; Pool 26 on both the Illi nois and Mississippi, with research con centration on the reaches above and below the new dam; and the Peoria Lake portion of Peoria Pool, on the Illinois River. They will start sampling Pool 19 this year, Poo 26 in 1983, and Peoria Pool in 1984. In tensive sampling will be conducted on each pool every third year, while less intensive monitoring will be continued on all pools every year.

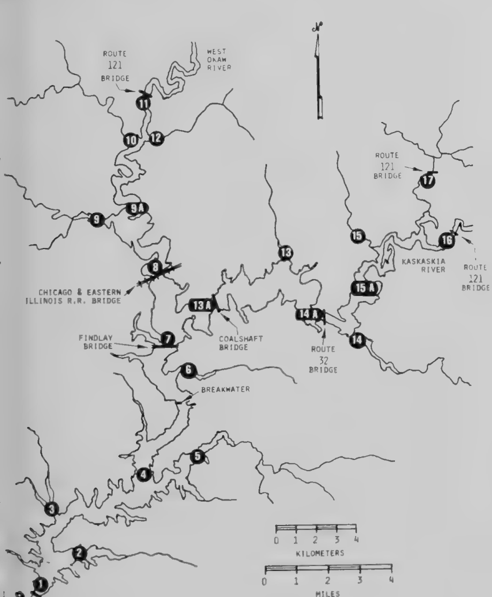
Pool 19 was selected because it is the oldest navigation pool on the Upper Mississippi River and is one of the most productive aquatic areas in the world. Peoria Lake is considered an experimental disturbed area on which the Surveys have good statistical data. Pool 26 provides an opportunity to study the ecological effects of a new navigation dam. This will be the first time that ecological data have been systematically gathered before, during, and after construction of a new navigation impoundment on the nation's largest river.

The Survey scientists have developed several predictions regarding effects of disturbances (both natural and man-made) on the plants, animals, and vital processes occurring in river ecosystems.

'he data gathered during the LTER 'roject will allow testing of these predic-ions and will form a substantial basis for leveloping environmental assessment pro-edures and for promoting management of he Illinois and Mississippi and other large iver systems in the nation.

Aercury Contamination Problem it Lake Shelbyville

Investigators in 1974 found that the nuscle tissue of largemouth bass from ,ake Shelbyville contained concentrations of mercury in excess of the 0.5-ppm limit et by the U.S. Food and Drug Administra-ion. These fish are near the top of the iquatic food chain, and thus the occur-ence of high mercury concentrations in heir tissues was indicative of mercuric ontamination at lower trophic levels and quite probably in the lake itself. Because Lake Shelbyville and its watershed are ocated in a prime agricultural setting with ittle industrialization, finding excessive mercury concentrations was unusual. A 3-year study to determine the cause, extent, and prognosis of the mercury contamina-tion problem was initiated by former Sur-vey analytical chemist Kenneth E. Smith and his associates and completed by pres-ent Survey chemist Susanne G. Wood and her associates.



'Map of Lake Shelbyville (Shelby and Moultrie coun-ties) showing sampling sites during mercury study.

Lake Shelbyville was formed by dam-ming the Kaskaskia River near Shelbyville, Illinois. The water was first impounded in 1969 and reached the calculated, normal pool level in 1970. For the purpose of the present study, 17 sampling stations were established in 1977 and 4 more in 1979 for the collection of water, soil, sediment, zooplankton, and clam samples, and 5 species of fish. Eight stations were at mid-lake, whereas the other stations were lo-cated on tributaries and creeks near their confluences with the lake.

The mercury concentrations in zoo-plankton, clams, and most fishes analyzed were within the range of natural abun-dance for unpolluted areas of the U.S.A. Comparisons of the mercury concentrations in fishes over the 3-year period indicate decreasing trends for gizzard shad, blue-gills, largemouth bass, and walleyes. If mercury concentration data for large-mouth bass and walleyes collected in 1974 and 1975 are included, the decreasing trends for these 2 species are even more striking. However, the mercury concentra-tions in carp increased during the 3-year period. Note that this species scavenges decaying vegetation, which is known to contain fairly high concentrations of mer-cury, in bottom sediments.

The planting of mercurially treated wheat and oats in the Lake Shelbyville watershed area during the 1950's and 1960's has been ruled out as a source of mercury contamination. Both the fre-quency of use of such treated seed and the quantity used were insufficient to cause a significant increase over the natural abundance level of mercury in the soils. Furthermore, in the lake itself there was no mercury concentration pattern impli-cating any particular station or area of the lake as the site responsible for the con-tamination. Thus, neither a point source nor a more generalized area source for the mercury contamination in Lake Shelbyville could be identified.

The typical conditions of highly organic sediments and submerged plant debris, both of which contribute readily to the cul-tivation of microorganisms capable of methylating and thus mobilizing mercury, are present in the lake. As a result, the bio-

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amplification of mercury in the Lake Shelbyville ecosystem has proceeded in an orderly fashion corresponding to increase in trophic levels of the organisms, namely zooplankton < clams < gizzard shad < bluegills < carp < largemouth bass < walleyes.

Thus, the suggestion that the source of mercury in Lake Shelbyville's ecosystem may be a secondary consequence of damming has considerable credibility. It is well known that the bulk of the mercury in soils is absorbed onto fine particles, especially the fine particles with high organic content, and these are readily suspended and swept along with flowing water. The rate of flow decreases as river or creek becomes lake, and much of the suspended particle load is deposited. Even more convincing evidence of high mercury content in suspended particulate matter is provided by the filterable sediment data.

Approximately half of the collected water samples contained mercury levels below the detection limit of the analytical instrument. For the remaining samples, there were no significant differences in mercury concentrations between stations or years throughout the study period. Because the water samples were not filtered, the small amount of mercury present in the samples, while somewhat above the 0.05-ppb limit for freshwater aquatic life set by the U.S. Environmental Protection Agency, may be related to the presence of particulate sediment matter.

Soil, littoral zone sediment, bottom sediment, and sediment core samples contained mercury concentrations well within the range of natural abundance. Nevertheless, the soil samples collected near the lake shoreline at tributary mouth stations contained 2- to 6-fold higher mercury concentrations than those collected at remote watershed sites. Filterable (runoff) sediment samples, however, contained mercury concentrations well in excess of the natural abundance and 3- to 10-fold greater than the concentrations in littoral zone or bottom sediment samples; these findings are probably reflections of the size of the filterable sediment particles and their concomitant greater affinity for mercury adsorption.

It is now known on the basis of this study and several similar studies that new impoundments undergo periods of extensive biological and chemical changes characteristic of the conversion from a terrestrial to an aquatic ecosystem. The mercury in soils both inundated by the impoundment and carried into the impounded water is generally in an immobile (inorganic) state. Decaying flooded vegetation and other organic matter contribute to the growth of microorganisms capable of mobilizing the mercury present in the soils. Bioaccumulation then occurs. The problem period usually encompasses the first 3-5 years after impoundment and is followed by a period of subsidence until system levels have stabilized. At this stage the impoundment is no longer "new."

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MAY 1981, NO. 217

ew Fern Hybrid Found in Illinois

The ferns and fern allies of North merica are well known, thanks to an ıthusiastic host of amateur and profes-onal botanists who have scoured the ountryside in search of these delicate and teresting plants. It is indeed rare to find new species or range record that has gone nnoticed, but recently Survey botanist obbin Moran discovered a new unde-ribed fern from northern Illinois.

The new fern is a member of the genus *ystopteris,* the bladder ferns. Perhaps the ıost interesting aspect of this fern's biology that it is of hybrid origin between the ulblet bladder fern and Mackay's bladder rn. The hybrid has been given the name llinois bladder fern, since it was first ound in Illinois.

The hybrid appears intermediate when ompared with its parents. One parent, the ulblet bladder fern, produces fleshy bulb-ts 5–10 mm in diameter on the underside f the leaf. These bulblets drop from the af when mature and vegetatively grow ıto a new plant. Mackay's bladder fern oes not produce bulblets. In the hybrid, ıe bulblets are small and scaly rather than ırge and fleshy. The leaf stalk of the hy-rid is darkened and brittle, a character cquired from the second parent. Overall, he shape of the leaf blade is intermediate etween those of the two parents. These ıtermediate characteristics first led to the uspicion that the plant was of hybrid rigin. Chemical studies further showed hat the hybrid contained phenolic com-ounds that were additive with respect to he unique phenolic compounds present in oth parents.

Moran found that the new fern existed in two different forms: plants with three sets of chromosomes and plants with six sets of chromosomes. When first formed, the plants have three sets of chromosomes; these plants produce aborted unviable spores and are therefore sterile. However, through quirks in the meiotic cell division process, viable spores are occasionally produced. These spores may eventually double their chromosome number, a process known as polyploidy, and form plants with six chromosome sets. The new plants, unlike their progenitors, are able to produce normal spores and are fully fertile. Thus, they

Herbarium specimen of the Illinois bladder fern. (Photo by Survey Photographer Les Woodrum)

can reproduce themselves and expand their range independently of their parents.

The hybrid and its two parents are found on rock cliffs and tallus slopes. A search of specimens from several Midwestern herbaria has revealed a total of seven locations for the Illinois bladder fern. The locations are centered around the Driftless Area where Illinois, Wisconsin, Minnesota, and Iowa meet. Two Illinois locations are known for the Illinois bladder fern, one in Lee County and the other in Winnebago County. Moran plans research trips to some of these sites to gain more knowledge concerning the biology of this interesting fern.

Alfalfa Weevil Fungal Infection

The fungus, *Zoophthora phytonomi,* has been recognized for many years as the most important natural control agent of the clover leaf weevil, *Hypera punctata.* In 1973 in eastern Canada researchers found an identical *Zoophthora* pathogen in larvae of the alfalfa weevil, *Hypera postica.* This fungus was first discovered in Illinois by Survey entomologists P. L. Watson, R. J. Barney, J. V. Maddox, and E. J. Armbrust in Washington County on May 9, 1979.

They conducted a study to determine whether humidity or photoperiod (the relative lengths of alternating periods of light and dark) was responsible for sporulation (the formation of spores) by *Z. phytonomi* in alfalfa weevil larvae. This study was also designed to determine the method and duration of the infection.

Alfalfa weevil larvae were collected from four Illinois counties and one Kentucky county and were held in cartons containing freshly cut alfalfa that was changed daily. Every 2 hours for 24 hours eight dead larvae were randomly selected and were placed in covered petri dishes containing non-nutrient agar, which served to maintain a high humidity in the petri dishes. Four larvae from each 2-hour period were kept in a 16-hours-light-and-8-hours-dark photoperiod at 78°F, while the other four dead larvae were kept in the reverse photoperiod of 8 hours of light and 16 hours of darkness. Every 2 hours the dishes were checked for the typical whitish halo of conidial spores surrounding any of tl larvae, indicating that sporulation had o curred.

After the entomologists had determin the timing of the sporulation, healthy a falfa weevil larvae were exposed to the i fectious spores by two methods. Twen potentially sporulating dead larvae we placed singly on agar disks, and each w inverted over a healthy larva of the secon or third instar (a stage in an insect's life in a separate petri dish. This method w called the shower technique. In the oth treatment, fungus spores were directly a plied to the alfalfa weevil larvae, and th was called the contact technique. Ten la vae in the second instar and ten in tl third were exposed to spores in each trea ment. All larvae were exposed to spores f 24 hours, and an alfalfa leaflet was pr vided to each larva for food during tl exposure. Larvae were transferred after 2 hours to separate rearing cages to comple their development at 78°F.

The researchers found that the phot period had no effect on the sporulation *Z. phytonomi* in alfalfa weevil larva Other scientists had found that peak spo ulation of the related fungus *Z. gamm* occurred between 4 and 8 hours after b ing placed in chambers having high hu midity. The same was shown to be tl case with *Z. phytonomi,* since the mea time required for dead larvae to produ conidial spore showers was 6.8 hours r gardless of the photoperiod used.

Other researchers had found that pea sporulation of the fungus *Z. gammae* o curred in the early morning hours. Most the sporulation in this study also occurre between midnight and 4 a.m. The ent mologists concluded that high humidi was the primary factor initiating sporul tion by *Z. phytonomi* in alfalfa weev larvae. They believe that sporulation b *Z. phytonomi* under field conditions prob ably occurs in the early morning hou when the relative humidity is the greates High humidity would protect the spor against rapid drying and inactivation an is conducive to further infections, as h been suggested by other scientists.

Infected alfalfa weevil larvae die within 7 days regardless of the method

fection. The rate of infection of larvae at were exposed to the spore shower was 5 percent. The contact technique produced infection in 25 percent of the larvae. However, no matter which infection method was used, all larvae exposed to spores as second-instar larvae produced infectious spores, while those exposed as third-instar larvae produced resting spores.

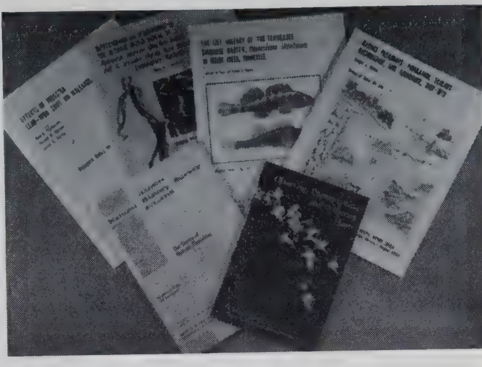
The finding that infectious or resting spores were formed, depending on the larval instar infected, was an unexpected result that may explain the timing of the fungal infection of alfalfa weevil larvae in the field and the quick occurrence and departure of the infection from the field in the spring.

Natural History Survey Publications Available to You

The mission of the Illinois Natural History Survey is to study and investigate the living natural resources of the state, prepare printed reports, and furnish information on the protection and conservation, development, and use of these resources. Survey scientists recognize that the final step in the research process is the publication of the results of research.

Consequently, Survey scientists write many reports each year, most of which are published in scientific and technical journals and some of which are published by the Natural History Survey itself. Most of these publications are available free of charge to residents of Illinois and to scientists and research organizations outside of Illinois. In the past year the Survey has published a 459-page monograph on 4 years of interdisciplinary investigations on the ecology of a power plant cooling lake and shorter reports on the life history of a small fish, the Tennessee snubnose darter; effects of ingested lead-iron shot on mallards; and the population, ecology, distribution, and abundance of Illinois pheasants. In the preceding year one Survey booklet was titled *Observing, Photographing, and Collecting Plants.* A 20-page brochure about the Natural History Survey has recently been published, and a list of Survey publications is also available.

To receive the list of publications, to request a publication, or to have your name placed on the mailing list for *Illinois Natural History Survey Reports,* write to Dr. Paul G. Risser, Chief, Illinois Natural History Survey, Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820.



Results of Illinois Natural History Survey research and information on how to apply these results are published as Survey Bulletins, Biological Notes, and Circulars, available free to Illinois residents. (Photo by Survey Photographer Les Woodrum)

Insecticide and PCB Levels in Woodcocks, Robins, and Mourning Doves

Levels of heptachlor, heptachlor epoxide, aldrin, dieldrin, p,p′DDE, and polychlorinated biphenyl (PCB) have been determined for muscle, liver, heart, brain, and fat samples from 15 woodcocks, 6 robins, and 8 mourning doves from east-central Illinois collected in 1979 and 1980 during an ongoing woodcock population ecology study by wildlife ecologist William R. Edwards and his associates.

Although pesticides were recorded at generally low levels, consistently lower than 1 part per million (ppm), all woodcocks were found to contain one or more of the six compounds assayed; the average woodcock had 2.4 of the six compounds. The same was true for robins, with an average of three compounds per individual, and mourning doves, with an average of 2.4 per individual. Of all 107 samples assayed, 3 (2.8 percent) contained heptachlor, 54 (50.5 percent) contained heptachlor epoxide, 1 (0.9 percent) contained aldrin, 86 (80.4 percent) contained dieldrin, 22 (20.6 percent) contained DDE, and 9 (8.4 percent) contained PCB's.

In general, it appeared that the insecticide loads of woodcocks and mourning

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doves were similar, whereas those of robins showed more individuals with heptachlor and heptachlor epoxide and fewer with dieldrin. The only incidence of aldrin occurred in a robin. Robins may have had a higher incidence of PCB's; however, sample sizes were small and the results cannot be considered conclusive. On the basis of food habits, the researchers anticipated that the insecticide loads of woodcocks and robins would be similar and that of mourning doves somewhat different, as the former eat large quantities of earthworms and the latter are considered largely seed and grain eaters. At this time the scientists can offer no basic explanation for the apparent anomaly in the insecticide loads of woodcocks, mourning doves, and robins from east-central Illinois.

Chlorinated hydrocarbon insecticides have been commonly used to control soil insects in corn since World War II. However, DDT has not been used extensively since the late 1950's. The use of aldrin declined after 1966 and effectively ended in 1976, as did that of heptachlor in 1978. Data from several studies in Illinois and elsewhere suggest that the incidence of DDE, and probably other chlorinated hydrocarbon residues, is declining in wildlife. This decline is probably not true of PCB's. Survey wildlife ecologists will continue to monitor pesticide levels in woodcocks and associated bird species.

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ATURAL HISTORY
SURVEY REPORTS

JUNE 1982, NO. [illegible]

llinois Agriculture and the Declining urvival Rate of Pheasant Chicks

The intensive use of land for agriculture a Illinois generally has caused declines in he abundance of wildlife. However, for nany species the actual mechanisms of uch declines are unknown. Wildlife ecolo-;ist Richard E. Warner is conducting a ong-term study of interactions between igriculture and ring-necked pheasant pop-ılations in Illinois. The findings of this esearch may illustrate the effects of leclining habitat for a variety of grassland pecies.

For example, information collected for pheasant populations in Illinois suggests hat over the past three decades the sur-vival of pheasant chicks has declined. The average number of eggs hatched per nest has remained relatively constant during this period. Yet the average number of chicks observed per brood along standardized routes near Sibley (Ford County) has declined from 6-9 during 1948-1954 to 6-7 during 1955-1959, 5-6 during 1960-1964, approximately 4 during 1965-1969, and 3-4 during the 1970's. Moreover the Illinois Department of Conservation's brood counts corroborate these trends for most of this state's pheasant range.

Pheasant chick requires insect diet during the first few weeks of life. Without it, there is little chance of survival. (Photo by W. E. Clark)

The decline in the survival rate of pheasant chicks may be a significant limitation for the abundance of pheasants in Illinois. Increased mortality of young pheasants appears to be related to the expanded production of corn and soybeans, with associated clean farming practices. Pheasant chicks require a near-total insect diet during the first few weeks of life. Traditionally, broods have foraged for insects in oat stubble and forage legume fields; such fields are nearly absent on the landscape in many parts of Illinois today.

It is plausible that the reduction in both quality and quantity of forage habitat for pheasant broods is in part related to the decline in pheasant numbers. Because a variety of grassland birds forage for food in similar habitats, the pheasant chick may be representative of a wide-spread decline in the survival of young birds in Illinois.

Rare Wasp Found

The wasp family *Rhopalosomatidae* has been found to occur in several states neighboring Illinois, but until now has not been recorded from Illinois. Three specimens were collected near Mahomet,

Champaign County, by former Survey entomologist Milton W. Sanderson in 1968 and recently were recognized in the Survey's Insect Collection by Survey entomologist W. E. LaBerge and identified as being *Olixon banksii* (Brues).

This wasp is about ¼ inch long, pale colored, has very short wings and cannot fly, and has extremely long hind legs. The females of *Olixon* pursue crickets, especially the common small brown or black ground crickets of the genus *Nemobius,* and lay an egg on the surface of the cricket. The larva which hatches from this egg remains attached to the cricket, feeding as an external parasite and eventually dropping to the ground to pupate and emerge as an adult wasp. The cricket begins to die and dies as the wasp larva reaches maturity.

It is likely that *Olixon* occurs throughout the state of Illinois, especially in wooded areas, although it has been collected only this one time. Its small size, inability to fly, and other habits make it easily overlooked by entomologists. The wasps were collected by Sanderson in pan-traps placed with their rims flush with the surface of the soil in a wooded area. About an inch of water with a drop of detergent is placed in the pan and insects that inadvertently drop into the water are unable to escape because of the lowered surface tension.

Because of its habits, *Olixon banksii* must be considered to be a beneficial insect, although of such rarity as to be not of great importance. How common or rare it actually is, however, has never been assessed.

Rare wasp, *Olixon banksii* (Brues), identified in Survey's Insect Collection. (Photo by David Voegtlin)

Water Resources: Assessment of Biotic Integrity

The surface waters of the United Stat absorbed pollutants as well as other in pacts of a developing society for sever centuries before signs of degradation cou no longer be ignored. A "dilution-is-th solution-to-pollution" approach to was disposal prevailed and typically resulted i grossly polluted water and associated loss of aquatic resources (particularly fishes By the mid-twentieth century, early legi lative efforts were initiated to halt an perhaps reverse this ominous trend.

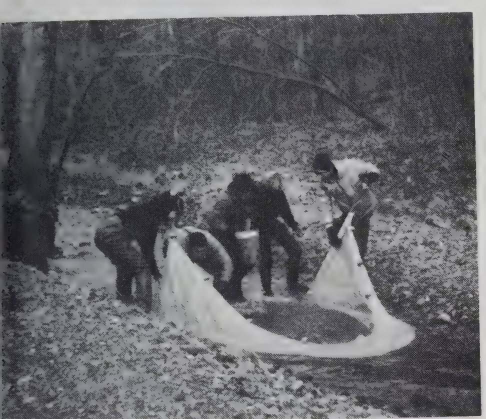
Passage of the Water Quality Ac Amendments of 1972 stimulated man efforts to monitor the quality of water re source systems and to control a host c societal effluents. The primary approac was to restore the chemical quality c water; it was presumed that improvement in biological quality would follow close a hand. In many cases streams were viewe as conduits for the transport of water an water development schemes rarely in cluded assessments of biological impacts As a result habitat quality and thus bioti integrity continued to decline in man areas despite massive expenditures of funds Ironically, man's "technological solutions to water resource problems sometimes con tributed to declines in biotic integrity (e.g. chlorine toxicity in the effluent of sewag treatment plants).

Recent legislation such as the Clear Water Act of 1977 clearly called for a more refined approach when pollution wa defined as "the man-made or man-induce alteration of the chemical, physical, bio logical, and radiological integrity o water." Despite this refinement, regulator agencies have been slow to replace the classical approach (uniform standard focusing on contaminant levels) with a more sophisticated and environmentall sound approach.

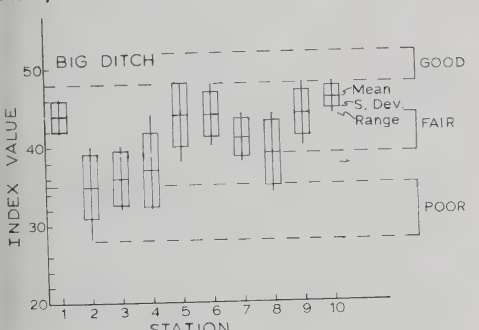
The integrity of water resources can best be assessed by evaluating the degree to which waters provide for beneficial uses. Important uses as defined by society may include water supply, recreational, and other uses as well as the preservation of future options for the use of the resource.

ince an ability to support a balanced otic community is one of the best indi-ators of the potential for beneficial use, phisticated monitoring programs should ek to assess "biotic integrity."

During the past few years, James R. arr, an affiliate of the Survey's Aquatic iology Section and Professor in the De-artment of Ecology, Ethology, and Evolu-on at the University of Illinois, has con-ucted research supported by the U.S. nvironmental Protection Agency that has esulted in the development of a new ystem for monitoring the quality of a vater resource. This system directly eval-ates biotic integrity through the use of a pecial index, a multi-parameter model imilar to the multi-parameter assessments sed by economists. The core of the system involves evaluation of about a dozen attri-butes of fish assemblages in streams. Pa-rameters include species composition and richness as well as several measures of trophic structure (food habits) in the assemblages. Additional parameters in-clude prevalence of disease and hybrid-ization.



Fish are collected for evaluation of effects of pollu-tion in Big Creek, Hardin County. (Photo by James R. Karr)



Change in Index of Biotic Integrity along a stream gradient (Big Ditch, Champaign County) from head-water (Station 1) to downstream (Station 10). Stations 2 to 4 are low because of sewage input between stations 1 and 2 and stations 7 and 8 are depressed because of the poor quality of habitat conditions. Generally low values (no good or excellent condi-tions) reflect the general agricultural land use in the Big Ditch watershed.

Fish are a logical group for assessment of biotic integrity because their natural histories are well known, they are relatively easy to identify, the general public can relate to statements about conditions of the fish community, and the results of studies of fishes can be directly related to the fishable waters mandate of the U.S. Congress.

The "Index of Biotic Integrity" can be used to rapidly and inexpensively assess the extent of water resource degradation. Where impaired use is suggested, a more complete monitoring program can be im-plemented to search for the causative agent or agents. With this approach, geograph-ically extensive and expensive monitoring programs can be scaled down at consider-able savings to society.

Researchers and planners from through-out the United States and a number of other countries have expressed interest in the Index. Testing and evaluation of the Index continues this year under a grant from USEPA. For more information con-tact James R. Karr, Department of Ecol-ogy, Ethology, and Evolution, 102a Vi-varium, (217) 333-1633.

Survey Speakers Available

In the spring of 1981, a Survey Speakers' Bureau was organized and researchers were asked to volunteer their services to the project.

Members of the Survey staff volunteered their services, agreeing to speak on a variety of subjects, among which are Water Pollu-tion, River Biology, Integration of Aqua-culture with Agriculture, The Rose Family, Illinois Wildflowers, Natural Areas, Butter-flies in Illinois, Research on Deer, and a general talk on the Illinois Natural History Survey.

Anyone wishing to engage a speaker should contact the Speakers' Bureau at (217) 333-6882.

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We ask that you take a minute of your time to fill out this questionnaire and return it as soon as possible

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2. Have you received a list of our publications within the last year? Yes____ No____
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3. Would you like to receive additional information (seminar announcements, publication fliers, etc.) in the area of:
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We appreciate your help. **If this questionnaire is not returned,** we will have to drop your name from our list due to increased costs of publishing and mailing.

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NATURAL HISTORY SURVEY REPORTS

SEPTEMBER 1982, NO. 219

Witches' broom on honeysuckle. Upper photo is appearance in summer (Photo by Les Woodrum) and lower photo is appearance in winter (Photo by David Voegtlin).

Alien Aphid Finds a Home

An aphid thought to be a native of Eurasia has been rapidly making itself at home on many of the species and hybrids of ornamental honeysuckles planted throughout the north-central states. The feeding of this aphid, *Hyadaphis tataricae* (Aizenberg), causes severe deformation of the growing tips, which are commonly called witches' brooms.

It was first found in the Montreal, Canada area in 1976. The first record in the north-central states is from Lake County, Illinois in the fall of 1979. The distribution and spread of this aphid was studied in detail during 1981 by David Voegtlin of the Illinois Natural History Survey. The aphid is very efficient at distributing itself and the movement of infested plants, such as nursery stock, is probably a major factor in its rapid spread. As of the fall of 1981 the aphid was found in Ohio, Indiana, Michigan, Wisconsin, Minnesota, Iowa, and Nebraska, as well as Illinois. The insect probably will continue its spread until it covers the area in which the host honeysuckles have been planted.

At present the following species and hybrids of honeysuckle have been found to be attacked by this aphid: *Lonicera tatarica, L. bella, L. minutiflora, L. muendeniensis, L. muscaviensis.* None of these is native to North America and planting any of these is a guarantee of future problems with this aphid. Most nurseries throughout the infested area are no longer stocking these because of the problem with this plant louse.

H. tataricae is specific to honeysuckles and will not feed on any other plants. The

witches' brooms can be of two types, pendulus or upright clusters. Both are formed by masses of increasingly small leaves which are folded in the middle with the upper side in, forming a pocket in which the aphids are located. To find the aphids one must open these folded leaves. The witches' brooms are a lighter color than the normal leaves and when the infestation is very heavy the outer parts of the plant take on a different hue. In late August and early September the witches' brooms die while the normal leaves remain green. After the regular leaves drop off in the fall, the damaged areas are highly visible, often retaining the tiny leaves throughout most of the winter.

Voegtlin says control can be obtained through the use of systemic insecticides. Local agricultural extension agents can recommend the current acceptable insecticides for use against the aphid. Spraying will have to be done often throughout the year as there is so much wild and planted honeysuckle during the summer that a continual supply of winged aphids reinfest the plants.

"Gob" Piles To Be Reclaimed

If you have ever driven on I-55 south of Joliet or on US-51 north of Bloomington-Normal, you may have noticed some large, conical, red and grey waste-rock piles. These "gob" piles are the remnants of the state's first industrial-scale coal mining district, the Longwall District, opened after the Civil War.

These mines had access to the booming Chicago industrial market, and in 1882 were producing 34 percent of the coal mined in Illinois. After 1906, however, their production was exceeded by the very large, more mechanized mines in southern Illinois. By 1924, their production dropped to 1 percent of the state's total. Finally, the Great Depression of the 1930's closed the era of the longwall mine.

Over the years, a number of factors have excited interest in the reclamation of these mine sites; the very prominence of the gob piles, the large acreages of many, their proximity to towns, their nuisance and harmful features, and, recently, the creation of the Abandoned Mined Lands Reclamation Council to clean up such problem areas in the state. The Council has granted a contract to the Illinois Natural History Survey to study these longwall waste piles to determine what kinds of reclamation are practical.

The mines of the Longwall District generally lie within 20 miles of the Illinois River between Morris and Peoria. Almost all old longwall mines in Illinois are found in this district; it is the only place in the nation where large tonnages of coal were mined by this method.

The longwall mining method can be compared to a spoked wheel. A vertical hoisting shaft — like the axle bore — entered the coal from the surface. Radiating from the shaft, like hollow spokes through the shaft pillar and the coal being mined were permanent tunnels called the "main entries." The main entries carried coal from the "working face" to the hoisting shaft and were extended as the coal was mined. The working face was the rim of the wheel where the coal was mined.

The miners worked crouched in the 3-foot-high seam opening. But along the main entries, they took down about 4 feet of roof rock to make 7-foot high ceilings and gave themselves and their mules headroom. Because all the coal was removed in the mine the rock overhead inevitably settled down into the mine openings. To keep the main entries open, they often had to clear falls and settlements out and haul the rock to the surface.

The largest of the gob piles are 180 to 190 feet high and cover 25 to 30 acres. Rains wash and gully their bare sides, carrying away mud and chemicals weathered from their pyritic shales. Grasses, weeds, and trees have not been able to take root on the steeper slopes of most of them.

It is the purpose of the Natural History Survey to assess the feasibility of revegetating the mined areas. Botanist Diane Szatoni and her associates will be examining the plant species that can survive on the barren gob piles and provide needed wildlife habitat.

During June and July 1982, an extensive literature review was begun. Special attention was given to plant species selection, soil amendments, and reclamation

ob" pile in the Longwall District.

ractices of the high plateau regions, the orthern Great Plains, and the eastern ituminous coal fields, where ecological onditions may be similar to those of the orth-central Illinois mines.

In addition, a preliminary inventory of lant species that occur on the gob piles uring the spring, summer, and fall was egun.

quaculture Workshop Held

The importance of the correct selection f fish and other components to suit the quaculture system was emphasized by Dr. Villiam Lewis, Southern Illinois Univerity, at a workshop, Aquaculture-Possibilties for Development in Illinois, held ecently at Levis Center on the campus of he University of Illinois.

Fish which grow rapidly, survive cold vinters, have a favorable dressed weight o live weight ratio, feed well on artificial eeds, and have a good market potential re most desirable. New species may have o be selected or developed. Genetic techiques are being modified which may enble scientists to develop and clone fish vith desirable traits especially adapted to quaculture systems, according to David Philipp, Survey fisheries biologist.

Although approximately 12,000 miles of treams and rivers, more than 240,000 acres of lakes and impoundments, and over 50,000 acres of reservoirs are located in Illinois, fewer than 2,500 acres are currently used for aquaculture production. Thousands of acres of marginal land in southern Illinois could be converted to aquaculture impoundment systems as well.

Marketing potential for fish and fish products is highly competitive with marine and freshwater commercial fisheries and with aquaculture products from the southern U.S. Creative production methods using thermal effluents, confinement systems, agricultural waste products as feeds (see Survey Reports, May 1980), and multiple cropping, coupled with shorter transportation routes, may make Illinois aquaculture products more competitive.

A study by Dr. Randy Westgren and Professor Margaret Grossman, University of Illinois, has shown that problems in the legal and regulatory environment in Illinois aquaculture are due to uncertainty and complexity in state laws brought about by a lack of recognition of aquaculture as a viable form of agriculture. Relatively minor modifications in both statutory and regulatory areas could result in an environment favorable toward aquaculture. It is also clear that the economic infrastructure must become familiar with the potential value of aquaculture before funds for facilities and equipment will be available to the producers from lending agencies (see Survey Reports, December 1980).

Several producers of catfish and other aquaculture products described problems which range from maintenance of valuable brood stock to oxygen depletion in ponds. In spite of these problems, they have maintained successful aquaculture operations for several years.

The future of aquaculture in Illinois seems dependent upon the wise use of

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genetically adapted fish to suitable aquatic ecosystems; efficient feeding, harvesting, processing and marketing methods; recognition and acceptance by selected agencies and modification of certain laws an regulations.

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NATURAL HISTORY SURVEY REPORTS

OCTOBER 198[illegible], NO. [illegible]

lack Cutworm Pheromone Trapping

The black cutworm, *Agrotis ipsilon*, can e a serious pest of seedling corn in the J.S. corn belt. Damaging larvae are hought to originate from eggs oviposited y female moths in fields in early spring efore the crop is planted. Many scienists believe that the moths that lay these ggs immigrate to the corn belt from outhern latitudes each spring. Consequently, early-season moth detection is imortant, especially since pest outbreaks end to be very sporadic.

Two Survey researchers, Eli Levine and William G. Ruesink, along with several other researchers from Ohio, Iowa, Indiana, and Missouri, recently conducted a tudy on the trapping of black cutworm (BCW) moths.

Once the sex pheromone (a pheromone s a mixture of chemicals released by the emale moth to attract a mate) system of this moth was identified, the researchers set out to determine if synthetic-pheromone (SP)-baited traps would improve early-season moth detection capabilities compared to the previously used black light (BL) trap (light used as a lure). Field studies were conducted in five major corn-producing states (Illinois, Indiana, Iowa, Missouri, and Ohio). In each state, SP traps and BL traps were placed in the proximity of corn or soybean fields and were examined for captured BCW moths at weekly intervals.

The results of these studies showed that SP traps were a more sensitive monitoring tool than BL traps during the period when it is most important to monitor moth flight activity; namely, between early April and early June. Through the first week in

Researcher Eli Levine examines two male moths caught in black cutworm pheromone trap (Photo by Les Woodrum).

June in each state, males were caught significantly sooner (on average, three weeks earlier) and in significantly greater numbers in SP traps than in BL traps.

From a pest management standpoint, it is important to know if female activity is closely related to that of males as measured by SP traps during early season. Evidence suggesting that SP trap catches of males better reflect early female egg-laying activity than do BL catches of females (SP traps catch only male moths, whereas, BL traps catch both males and females) was provided by a concurrent study where the reproductive condition of females from BL traps was examined. In this study, it was found that older mated females were the dominant forms during the early season. On the basis of this finding, it was concluded that females had deposited significant numbers of eggs preceding their capture in BL traps, and therefore, the first capture of a male in a SP trap would probably serve as a useful reference point to denote the start of egg

laying in the central Corn Belt. A BCW development model (created and refined by Steve Troester, another Survey researcher), initiated with this information, could then be used to predict the occurrence of damaging larvae. This model will provide corn producers with information on the time (date) when they should actively scout their fields for this pest. Indeed, Illinois, Iowa, and Ohio are already using data from SP traps as a basis for computer prediction models.

Winterizing Roses

Every year people lose many rose bushes during the winter. Survey botanist Ken Robertson observes that there are several ways to eliminate or minimize this problem: 1) don't grow roses, 2) plant new roses every spring, or 3) perform some preventive maintenance. These notes have been prepared for those who select alternative number 3.

Several basic types of roses are commonly grown in Illinois — hybrid teas, grandifloras, floribundas, climbers, tree

Beautiful roses are ample reward for the conscientious grower (Photo by Ken Robertson).

roses, and shrub roses. The vast majori of cultivated roses have beautiful b anemic stems that are grafted onto th roots of vigorous wild-type roses. Th graft, or bud union, results in a knuckl like knot of wood at the base of the sten and the joint is very vulnerable to col temperatures. When planting rose bush in most parts of Illinois, the roots shoul be positioned so that the graft joint located approximately 1 inch below th surface of the soil. This layer of soil wi help protect the most cold-sensitive pa of the rose bush from winter temperature

In addition, most roses will benefit fro additional winter protection. Robertso stresses that NONE of the followin should be done until AFTER the plan have gone domant and there has been HARD, killing frost; if this warning is n heeded, more harm than good will be don to the plants.

To protect hybrid tea, grandiflora, an floribunda roses, tie the canes together an cover the lower part of the plant with mound of soil (or grass clippings) to height 6″-8″. Do NOT obtain this so from the immediate vicinity of the ros bush since this will damage the plant' roots. Then, cover the rest of the lowe part of the plant with straw, hay, or styro foam rose caps or cones. The plant ca be dusted or sprayed with rose pesticide before making the mound. Plants may als be pruned back somewhat before covering but it is important not to prune ver heavily because the ends of branches ar killed back during the winter, and if th plants have been closely pruned, this ca damage major stem branches.

The common climbing roses do not nee special winterizing, although the base o the plant can be protected with a moun of soil, as outlined above. Some of th fancy varieties are rather tender. To pro tect these, tie the canes together and ben them over and use stakes to hold the cane parallel to the ground. Then cover th canes with a layer of soil and/or hay.

The techniques outlined above for hy brid teas and climbers can be used fo some shrub roses, while other shrub rose require no winter protection at all. Tre roses require rather specialized winter pro

ction, and information on how to do this available at garden centers and in rose re books.

As Robertson says, roses are beautiful ants and have an aura of mystique about em, having been cultivated and revered nce Classical times. However, roses are ot for everyone's garden. Rather, like an xpensive sports car, they are for people illing to give them considerable attention. hese people find their efforts are more ian amply rewarded.

tudy Begun at Jade Acres

A study to determine the feasibility of reating a rural center of appropriate nergy and agricultural technologies has een initiated by the Illinois Natural Hisory Survey. Offered as a gift to the State f Illinois by Dave and Jane Fletcher, the te for the proposed Illinois Appropriate echnology Research and Education Cener is at Jade Acres near Salem, approxiately five miles from I-57 at the Alma xit.

The 50-acre rural site is representative f the hilly, sparsely wooded, marginally gricultural land typical of southern Illiois. Surrounded by a 7-foot chain link ence with a large brick and iron gateway, he farm offers an impressive and beautiul site for research and demonstration. Extensive security measures protect the iouse and buildings.

The 9,000-square-foot English Tudor nansion, constructed in 1976, is well built ind well appointed. Many construction changes added to conserve energy have effectively reduced heating and cooling costs. The home will be available for multiple usage, including conference center, ibrary, laboratories, and offices. Additional outbuildings include a storage and loafing oarn, milking barn, kennels, smoke house, and summer kitchen. The latter is well equipped for food processing activities. The estate has an in-house computer and tools and equipment for farming, gardening and workshop.

For the past six years, the Fletchers have developed the farm on organic principles. Pastures, woodlots, gardens, orchards, and pond banks have been planted with a variety of biomass- and food-producing


The mansion at Jade Acres will offer facilities for the interdisciplinary research of the Survey (Photo by Mitch Beaver, Dept. of Energy and Natural Resources).

perennials. Also on site are a dairy goat herd, chickens, ducks, cows and honey bees.

The planned center will be an integrated system of energy and agricultural technologies which are efficient and effective for individual homeowners and small farms. Wind, solar and biofuels technologies will be coordinated with alternative agricultural methods, including permaculture, vegetation biomass, aquaculture and dairy goat production. Research in and modification of existing methods will be an important aspect of the center. A primary goal of the program is to demonstrate soft alternative appropriate technologies which are cost-effective on marginal lands.

A site director and advisory group are being sought for the feasibility study. Volunteers interested in working on the site in exchange for room, board, and valuable experience should contact: Mr. Dave Fletcher, R. R. #4, Salem, IL 62881, or telephone 618-548-4473.

Pheasant Hunting 1982-1983

The ring-necked pheasant is the most popular game species in Illinois. Both the hunting and nonhunting public consider the gaudy ringneck to be a symbolic and highly visible representation of the Prairie State's rich wildlife heritage. Thus, it is not surprising that recent declines in pheasant numbers have captured the attention of the public.

Indeed, not all has been well with Illinois pheasant populations in recent years. For example, from 1973 through 1978, the

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relative abundance of pheasants declined 84% range-wide in Illinois. Declines in numbers of pheasants during the late 1970's and early 1980's have been largely the result of unusually severe winter weather. The critical long-term factor, however, has been the destruction of habitat. As farms in Illinois have become increasingly corn-soybean enterprises, forage legumes and small grains — prime pheasant habitat — have become scarce on the agricultural landscape.

In spite of the relatively sparse numbers of pheasants at present, wildlife ecologist Richard E. Warner suggests that there are some factors hunters should consider in order to improve their success in bagging a rooster. First, hunters should be aware that the patterns of relative abundance and distribution of pheasants have changed substantially in Illinois over the past decade. Hunters who traditionally traveled to east-central counties should now consider arranging trips to Mason County, or northern counties such as Carroll, De Kalb, Kendall, Lee, Ogle, Stephenson, Will, Winnebago, or Woodford. Secondly, parties should seek permission to hunt on farms that still produce hay and small grains, and that have unplowed grain stubble and permanent vegetation remaining over winter. Lastly, Warner recommends that hunters be more per sistent. In recent years, a high percentag of pheasant hunters put their guns awa for the season after opening weekend Often, however, the best pheasant huntin occurs later in the season, after the firs snowfall and colder weather.

Researchers have concluded that th sport hunting of cock pheasants does no adversely affect reproduction by he pheasants the following spring. Investiga tions have also shown that releasing pen raised pheasants generally does not en hance self-maintaining populations. Illinoi pheasants would benefit primarily fron habitat improvements. The Illinois De partment of Conservation offers program to private land owners that will enhanc wildlife populations on their land.

Agricultural land use policies will i the future largely contribute to the statu of Illinois pheasants. In some regions o Illinois, the production of row crops ha resulted in severe soil erosion. Crops tha enhance or protect topsoil, such as grasses legumes, and small grains, are relativel beneficial to pheasants. In general, pheas ants and pheasant hunters would greatl benefit from agricultural policies and pro grams that would both mitigate soil loss and prevent an oversupply of feed grain in the market place.

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NATURAL HISTORY SURVEY REPORTS

Hold That Tiger!

In an effort to improve the balance between predator and panfish populations, increase the diversity of the angler's catch, provide a trophy fish, and increase the growth of stunted panfish populations, Survey researchers have introduced the tiger muskie into some small lakes and ponds of Illinois.

The northern pike, muskellunge, and their hybrid offspring, the tiger muskie, are among the predator species that have been used to complement the largemouth bass. All three of these fishes achieve greater maximum size than largemouth bass and are able theoretically to eat larger bluegill than are normally selected by bass. Because they are cool-water species they exhibit seasonal peaks in food consumption in the spring and autumn; thus, they may complement the feeding activity of the largemouth bass which feeds most heavily in midsummer.

The tiger muskie is a hybrid which has proven superior to both parents in many hatchery situations and possesses characteristics which also make it useful to the fishery manager. The tiger muskie is believed to be intermediate between parents in angling vulnerability and may therefore contribute to the harvest without being overexploited. Furthermore, there is evidence that the tiger muskie has a higher survival and growth rate than either parent and is more tolerant of high summer water temperatures often experienced in Illinois.

In 1982 aquatic biologists began a 3-year study to evaluate the impact of tiger muskies on the bass-bluegill combination in small impoundments. The study objectives are to determine the survival, growth, hooking mortality, food habits, and spillway escapement of tiger muskies as well as the impact of these large predators on bass-bluegill populations.

The value of the tiger muskie as a management tool will not be established until the end of the project, but some useful data have already been obtained. Most of the tiger muskie research is being conducted at Ridge Lake, a 15-acre experimental fishing lake operated by the Survey in cooperation with the Illinois Department of Conservation. The lake was stocked in the summer and autumn of 1981 with largemouth bass, bluegill, channel catfish and 150 eight-to-ten-inch tiger muskies.

At Ridge Lake, tiger muskies are quite vulnerable to capture by hook and line, but survival of hooked fish is reasonably good. Over 40 percent of the number of stocked tiger muskies were caught during the 1982 fishing season, but only 10 percent of these died as a result of the hooking experience. Good growth, indicated by an approximate doubling in length in one year, suggests that a bass-bluegill population can provide

Tiger muskie caught at Clinton measures 35 inches in length and weighs 10 pounds (Photo by Dennis Newman).

adequate forage for tiger muskies. However, the food selected by the tiger muskies is an important consideration. If largemouth bass are eaten frequently, the potential value of the tiger muskie will be greatly compromised.

The lake was opened to fishing in April of 1982 and remains open each year until October 15. Since all fishermen must pass through a single checkpoint to gain access to Ridge Lake, harvest data relevant to the tiger muskie research are easily obtained. Also, since Ridge Lake can be completely drained, it will be possible to collect precise survival and growth information on tiger muskies and associated species at the end of the projects. Two other impoundments, stocked with tiger muskies in September of 1982, will provide information on the food habits and bluegill population control capabilities of this species.

Effects on Economic Injury Levels Of Weed/Defoliation Interactions

Current integrated Pest Management systems rely on established economic injury levels for control decisions. Economic injury levels have been established for many soybean insect pests, but few are available for the major weeds, diseases, and nematodes; none exist that take into account the concurrent effect of multiple pests. The actual field situation, however, is one where many pests coexist and their effects are likely to be increased as a consequence of the multiple-pest interactions.

A major difficulty in establishing economic injury levels for multiple pests relates to the complexity of the experimental design necessary to measure the various interactions. For example, economic injury levels for defoliating insects alone are tested using a randomized complete block design with various levels of defoliation effected at various stages of plant growth. As another pest is added, the design changes to a split-plot and each new pest requires a new split. Not only does the design become cumbersome, but in the past, the implementation of the experiment was almost unmanageable.

During the past two growing seasons, a method has been developed that permits adequate testing of the combined effects

Researcher Michael Jeffords spraying a plot af[ter] defoliation was completed (Photo by Marcos Koga[n])

of defoliation and weed competition. Th[e] work of researchers Charles Helm, Micha[el] Jeffords, and Marcos Kogan used a com[-]mon broadleaf weed — velvetleaf, *Ab[u]tilon theophrasti,* and the soybean loope[r] *Pseudophesia includens.* The test is estab[-]lished on a one-acre matrix of convention[al] soybean of a common commercial variet[y]. They applied a grass herbicide and use[d] hand weeding to eliminate other unwante[d] broadleaf weeds.

Velvetleaf seedlings were grown in th[e] greenhouse and at crop emergence th[e] plots were established with previously se[-]lected weed concentrations — four weed[s] per plot in 1981 and four and eight i[n] 1982. Approximately two weeks prior t[o] the date at which defoliation was to b[e] effected, the 6 x 6 feet plots were covere[d] with walk-in saran cages. Defoliation wa[s] produced by feeding of soybean loope[r] larvae.

The soybean looper is well adapted t[o] soybean but usually does not eat velvetlea[f]. Each plot's larval population resulted fro[m] eggs oviposited by 100 female moths re[-]leased inside each cage. The progress o[f] defoliation was carefully monitored unti[l] it approached the desired levels (60% i[n] 1981, 30% and 60% in 1982). Rando[m] samples of 10 leaflets were taken from eac[h] cage and the actual defoliation level wa[s] measured with an electronic leaf-are[a] meter. When defoliation reached the de[-]sired level, the cage was removed, and th[e] larvae killed with a spray of methomyl. I[n] 1981 it was determined the cage had n[o] effect on yield so no control was necessar[y] for the variable in 1982.

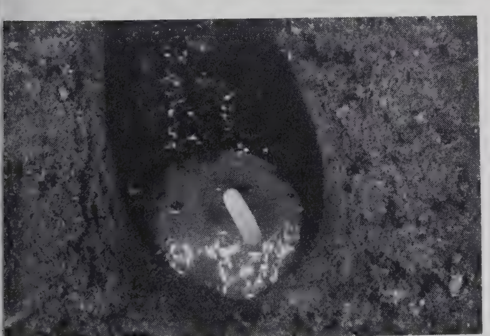
Synchronization of all operations is es-
ntial. The insect culture in the laboratory ust be handled so that ovipositing moths the correct quantities are available at e proper time.

This experimental procedure permits the erformance of rather complex testing in a latively small area and with a lower de-and for labor. Defoliation is natural and as none of the drawbacks of simulated jury (hand-defoliation). A similar ex-erimental design is now being considered volving superposition of a third class of est — a leaf disease. Analysis of the 1982 xperiment awaits yield data but the Sur-ey scientists are confident, from the ob-rvations made so far, that the design is atisfactory and should provide a good first pproximation for the establishment of conomic injury levels of weed/defoliation teractions.

iology of a Wild Bee

Honeybees and bumblebees are among e most familiar and conspicuous insects. he honeybee, well known as a producer f honey and beeswax and as an important ollinator of many crops, represents but a ingle species of insect, *Apis mellifera*. It is ot native to this country, but was brought rom Europe by the early settlers of North merica. Bumblebees, large, hairy, usually lack and yellow insects, represent a num-er of species in the genus *Bombus*, all of hich are native to this country.

In addition to these, there is a much arger group of bees (in terms of number f species) known collectively as native, olitary, or wild bees. There are perhaps 0,000 species of wild bees in the world and about 350 of them can be found in Illinois. They are a diverse group both in appearance (some being less than a quarter inch long, others as large as bumblebees) and in behavior. Wild bees are important pollinators of many native shrubs and wild-flowers as well as commercially valuable plants such as fruit trees and alfalfa, a fact that is often overlooked or little known. Because of their interesting behavior, wild bees have been the subject of considerable scientific research and the taxonomy of the superfamily Apoidea (taxonomic group that includes all bees) is one of the best known of any group of insects.



Cell of *Andrena erythrogaster* showing pollen mass with egg laid on top of it (Photo by David J. Voegtlin).

Graduate student Eugene Miliczky, under the direction of Survey entomologist Wallace E. LaBerge, has been studying various aspects of the biology of several species of native bees belonging to the genus *Andrena*. Of special interest are three species of *Andrena* that feed their young almost exclusively with pollen gathered from various species of willow trees. These three species, like many other species of wild bees, have an adult stage (the winged, reproductive stage) that is active for only a short time each year. The rest of the year is spent underground, in hollow twigs, and in similar locations (depending on the species) as an immature form or as a "resting" adult. Adults of the three willow bees can be found in the Champaign area from late April until the middle of June. At this time the adults have died off and will not be seen again until spring. Their young, however, have been well provided for.

Available information indicates all species of *Andrena* dig nests in the ground. *Andrena erythrogaster,* one of the willow bees, is no exception. Nests of this bee, sometimes called the red-bellied bee because of its bright red abdomen, were found in the woods at Lodge Park in Piatt County. Fifteen nests were located and studied during the spring of 1981 and a smaller number in 1982. Each nest was occupied by a single female bee that dug through the well packed dirt using her mandibles (one of her mouthparts) and legs. The resulting burrows descended nearly vertically into the ground for depths of 6-10 inches. Soil from the burrow was

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pushed to the surface by the bee and made a mound that resembled an ant hill around the entrance.

At various points along the main burrow the bee dug horizontal branches an inch or two in length. At the end of each branch a cavity or cell was made. The cells were oval in shape, about a half an inch long and a quarter inch in diameter. The walls of the cell were made very smooth by the female bee and she then applied a waterproof secretion to them. At this time the bee began to gather pollen and nectar.

Several loads of pollen and nectar were brought back to the nest and placed in the cell. They were then mixed together and shaped into a somewhat flattened sphere. An egg was laid on top of the pollen mass and the branch burrow leading to the cell was tightly packed with soil. The female bee had no further contact with the egg or the larva that hatched from it. She had, however, provided enough food for the complete development of a new bee. The larva that hatched from the egg consumed the entire pollen mass and then pupated. By early autumn the pupa gave rise to an adult bee which remained in tl cell over the winter. This bee, representir a new generation, dug its way out of tl soil the following spring when the willov were once again in bloom.

The hard-working female bees probab rear seven or eight offspring each in a average year. By the end of their lives the mouthparts have been worn down by dig ging, their wings are tattered, and much c their hair has worn off. Exhausted by con stant work, they die and can be found fre quently at the bottom of their nests. I contrast to the females, male bees mak very poor fathers. Their primary concern in life are finding and mating with one o more females and locating sources of necta on which to feed. They take no part in digging the nest or providing for th young.

The nesting biology of willow bees i one phase of this research. Others concern the foraging behavior of the different spe cies of willow bees, phenological relation ships of the bees and the species of willows they visit, and the role of bees as pollina tors of willows.

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ATURAL HISTORY
URVEY REPORTS

DECEMBER 1982, NO. [illegible]

cords of North American Big Game

The Section of Wildlife Research of the inois Natural History Survey was host ently to a training session to certify icial measurers for the Boone and Crock- Club. The session was jointly sponsored the Illinois Department of Conservation d the Boone and Crockett Club. Glen nderson, head of the Wildlife Research ction at the Survey, has been the only icial measurer in Illinois for the past 17 ars.

Sixteen biologists, veterinarians, and ldlife managers attended the four-day ining session. Two were from Illinois; ree from Missouri; and one each from wa; Indiana; and Alberta, Canada.

The Boone and Crockett Club made its st formal recognition of outstanding big- me trophies in North America in the lub's 1932 records book. This first recog- tion involved only a few specimens and nple measurements such as length and spread of horns, antlers, or skulls. The records book of 1932 was followed in 1939 by a records book that included many chapters on a variety of subjects related to big game and hunting.

ngaged in measuring are (left to right) Forrest oomis, Department of Conservation; Al Woolf, outhern Illinois University; Mike Cochran, Depart- ent of Conservation; and W. H. Nesbitt, Boone and rockett Club.

The Club held its first "competition" for outstanding trophies in 1947. These trophies were ranked by a series of measurements that were refined in 1950 into the present scoring system for trophies. Since the 1947 "competition," there have been 17 Awards Programs, as they are now called. In recent years, the Awards Programs are held after the close of a three-year period of entry of trophies.

Trophies are measured by official "measurers" certified by the Boone and Crockett Club. Because Sanderson has been the only official measurer in Illinois, individuals with trophies to be measured often had to make a trip of several hundred miles in order to have a trophy measured. Although a variety of big game animals are measured — bears, cats, walrus, elk, deer, moose, caribou, pronghorn, bison, Rocky Mountain goat, muskox, and wild sheep — the species most often measured in Illinois is the white-tailed deer. Primarily because of increasing interest in "trophy" white-tailed deer in Illinois, for several years Sanderson has been encouraging the training of additional official measurers for Illinois. This interest was shared by Forrest D. Loomis, Forest Wildlife Supervisor, Illinois Department of Conservation.

The course was conducted by Harold Nesbitt, Secretary, Records of North American Big Game Committee, and his assistant Al Manville from the Club office in Alexandria, Virginia. Nesbitt took graduate training in wildlife management at the

Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale. The instructors brought several examples of the various types of big-game trophies and used them in the training sessions. Many local sportsmen, and other interested individuals, examined these trophies during the training session.

The name "Boone and Crockett" has long been associated with big game trophies in North America, and the record keeping program for native big game species is one of the Club's better known activities. However, this activity is only one of the many conservation activities of the Boone and Crockett Club. As part of these activities, the club regularly sponsors graduate-level wildlife research, primarily on big-game species. Recently the Club sponsored two workshops on the life history and management of the black bear and the wild sheep in North America. The results of these two workshops have been published in paperback books. Eight editions of *North American Big Game* have been published by the Club. These books are valuable handbooks for trophy hunters, wildlife managers, and students of big-game populations. The eighth edition, published in 1981, lists the trophies added during the 1977-1979 period to those listed previously and brings the total to nearly 7,000 individual trophies in 31 categories. Entries for the 1980-1982 awards must be postmarked no later than December 31, 1982.

Individuals who wish information on the Boone and Crockett programs and awards should write to Boone and Crockett Club, 205 South Patrick Street, Alexandria, Virginia 22314. Residents in Illinois interested in having trophies measured should contact Forrest D. Loomis, Illinois Department of Conservation, 125 North First Street, Monmouth, Illinois 61462.

Aquatic Insects and Oligochaetes of North and South Carolina

A recent publication, *Aquatic Insects and Oligochaetes of North and South Carolina,* edited by Allison R. Brigham, Warren U. Brigham, and Arnold Gnilka, is the first comprehensive account of these elements of southeastern fauna. This work should serve not only as an introduction the beginner, a working manual for aquatic biologist, and a handy reference the specialist, but also should provide stimulus to further investigation into fascinating area of biology.

It treats approximately 2,500 species 837 pages, and has over 2,000 illustratio plus a systematic index. The book is outgrowth of the long tradition of aqua research and faunal studies established the Illinois Natural History Survey o the last 125 years. The Survey's scienti collections provided a rich source of specimens for the study, and the authors we able to use many of the excellent illustrtions of insects which have appeared past Survey publications on the Illin fauna.

In late 1973, Duke Power Compa asked Allison R. Brigham and Warren Brigham of the Illinois Natural Histo Survey, and Arnold Gnilka of Duke Pow Company, to put together a team of biolgists in order to conduct a faunal stu and prepare an identification manual f the freshwater benthic macroinvertebrat in their service area (the piedmont regi of North and South Carolina). In additi to A. R. Brigham and W. U. Brigham, M W. Sanderson, J. D. Unzicker and D. W Webb of the Survey took part in the proect. Other authors included specialis from the University of Michigan, Univesity of California, Eastern Illinois Univesity, Clemson University, Kansas State Bilogical Survey, and the states of Nor Carolina and South Carolina.

Originally the manual was conceived an in-house document to be used by Duk Company's staff to provide accuracy identification of benthic macroinvertbrates in their biotic surveys and lon term monitoring programs in the Carolina As the project developed, the scope of th study was expanded to include the faun of all three physiographic regions (mountain, piedmont, and coastal plain) North and South Carolina. In additio the authors were asked to review the Nort American literature on the biology of the organisms, and synthesize it into a singl comprehensive work.

Each chapter of the book covers an der of insects plus the aquatic worms or *ligochaeta.*

ological Control of the Musk Thistle Illinois

About 120 years ago, the musk thistle as introduced accidently into Pennsylmia from Europe. Without its natural iemies to suppress its reproduction, it read quickly to inhabit roadsides, pasires, and waste areas throughout much of ie United States. In Illinois, the weed rows well particularly in strip mine areas mverted to pastures.

In an attempt to control this weed biogically, Illinois Department of Agriculire personnel, in cooperation with the llinois Agricultural Experiment Station, eleased a weevil native to Europe, *Rhinoyllus conicus,* at six locations in Illinois uring 1979 and at three additional locaons during 1980. After the initial establshment of the weevil (see *Natural History urvey Reports,* September 1980, No. 199), s populations and their effect on musk histles have been monitored through a oint effort of the Illinois Department of griculture and the Illinois Natural History urvey.

The weevils overwinter as adults and enerally are seen first on thistles in early May. Adult feeding at this time causes mall brown spots on the leaves; however, his has little effect on the plant. After eeding and mating, the females lay eggs n the bracts of developing flower heads. The larvae hatch from the eggs and bore nto the base of the flower or receptacle.

The primary damage to thistles is aused by the larvae. Larval feeding in the eceptacle prevents the development of some or all of the seed within the head. To prevent the development of all seeds withn a head about 20 larvae must inhabit a seed head. At a certain stage of developnent the larvae stop feeding and pupate within a hard brown chamber in the receptacle. In a few days the final change from pupa to adult takes place. By the end of July, the new adults leave the heads to find overwintering sites, and become dormant until the next spring.

Larvae of the musk thistle weevil, *Rhinocyllus conicus,* feeding within the receptacle of a musk thistle seed head (Photo by William Lamp).

Weevil populations have been increasing slowly and destroying more seeds each year since the initial releases in Illinois. At a release site in Fulton County this year, Survey Research Associate William Lamp found nearly 90 percent of the terminal seed heads contained weevils and that the weevils had spread to thistles about a half mile away. Last year, 62 percent of the terminal heads contained weevils. A similar pattern of population buildup and dispersal during the first five to seven years is common among release sites in other states, and is usually followed by a rapid increase of weevil populations and a decrease in thistle seed production.

The weevil generally attacks the first flower heads developing on a thistle and allows heads developing later to produce their full complement of seeds. At the Fulton County site, up to 17 larvae inhabited the terminal heads, but the laterblooming lateral and axillary heads were usually free of weevil attack. The larval stage of another insect species, *Homoeosoma ellectellum,* the sunflower moth, was often observed feeding on thistle seeds. The adults of this insect commonly attack the native sunflowers and usually cause little damage to the musk thistle.

The weevil is not expected to eradicate the musk thistle, its only host plant in Illinois, but rather to reduce its population to a low level. If further reduction of thistles becomes necessary, additional biological control agents may be released. U.S. Department of Agriculture researchers are currently investigating other insect

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species that may be released in the USA. As with all biological weed control agents, these insects are tested to make certain they will not become pests on crops and other beneficial plants.

The impact of the weevil on musk thistle populations up to this time is difficult to assess. Although original stands in which releases were made have almost disappeared, new stands have developed i nearby areas. This reflects the patchy di tribution of the thistle, with the locatic of stands shifting between generation Once the weevil severely reduces seed pr duction, the establishment of new thist stands and their subsequent populatio growth are expected to decrease.

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ATURAL HISTORY
URVEY REPORTS

JANUARY 1983, NO. [illegible]

ction Wounds and Tree Growth

ertain nutritional, pathological, or omological maladies of trees can be edied by implantation or injection of micals into the trunks of trees. Ex- oles of two treatments that may be rec- nended by Survey pathologists are ection of lime-induced iron chlorosis oin oaks with implants and treatment of pient stages of Dutch elm disease in cimen elm trees with injection proce- es. Trunk wounds are required prior to tment and wound size is a major factor determining the method of treatment.

revious experiments have determined t wound closure is correlated with und width and tree growth. A recently npleted study by Dan Neeley, Survey nt pathologist, was designed to deter- ne (1) if intentional wounding over a iod of years would result in reduction of e growth, and (2) the correlation be- een tree growth and wound size.

Trees of five species at two locations, the vey arboretum south of Urbana and the Morton Arboretum west of Chicago, were treated for four years (1977-1980). Wounds were of two types: circular and pointed elliptical. Four whorls of circular wounds were cut into the trunks at three-inch intervals: the whorls were one foot apart. The circular wounds were 3/8, 1/2, and 11/16 inches in diameter. One whorl of elliptical wounds two inches tall and one inch wide was cut into the trunks at three-inch intervals each year. Trunk diameter increases and wound closure were measured annually.

The wounded trees grew just as rapidly as the untreated trees. It would appear that wounding of trees for injection or implantation of a chemical will not measurably slow tree growth if the chemical itself is not toxic to the tree.

Although there was a difference among tree species, the 3/8-inch wounds closed in one season with .10 inch, 1/2-inch wounds with .15 inch, and the 11/16-inch wounds with .23 inch of radial growth of the tree trunk. The larger the wound, the lower the

Following drilling holes in the trunk, the tree is pressure injected with chemicals that aid in remedy of some vascular diseases (Photo by Eugene Himelick).

number of wounds that completely closed the first season. In these test plots, essentially all of the 3/8-inch wounds closed, 80 percent of the 1/2-inch wounds, and 50 percent of the 11/16-inch wounds closed in one year. This confirms the suggestion that wounds should be as small as practical when using implant or injection techniques.

Biological Collections

Collections of biological materials contain enormous amounts of information. This information is contained in the specimens themselves as well as in the recorded information taken at the time the specimens were collected in the field. The amount of information with the collections increases with the passage of time. This is because the collections record events in history and these data can be used as a comparison between the past and the present.

The most obvious use of collections is for the identification of organisms. For example, if an unknown specimen is sent to the Illinois Natural History Survey for identification, the scientist frequently goes to the collection to compare this specimen with previously collected organisms. Without the collections, it would be more difficult, often impossible, to identify many plants or animals which are collected today. These identifications are frequently of economic importance, perhaps as pest species.

Collections also represent a record of the changing distributions of species. By going to the records, it is possible to decide whether man's activities have had an adverse effect on animal and plant populations. For example, a citizens' group might maintain that a power plant has not decreased the number of fishes in a given stream. However, by reviewing collection records, it might be possible to show that the stream previously contained much larger fish populations and therefore the power plant could be made to assume the responsibility for the decreased number of fishes.

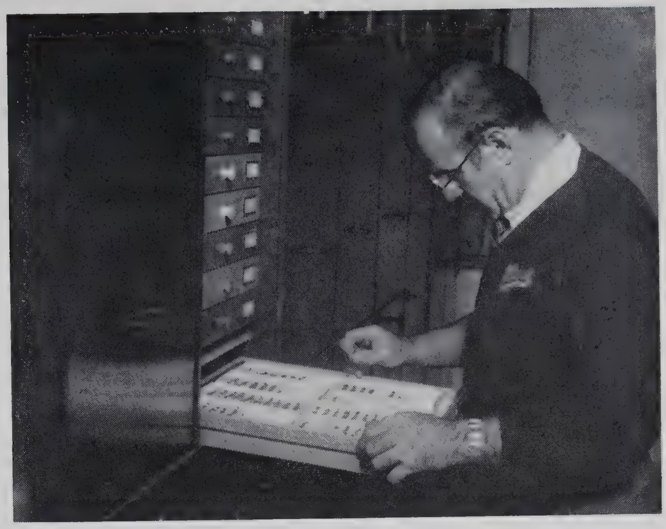
Two other examples indicate ways in which the collections are frequently of great economic value. In 1975, an unknown insect was found infesting soyb fields in southern Illinois. The farm immediately began spraying because t thought this insect carried a bacterial ease which kills soybeans, the tobacco r spot. Scientists from the Illinois Natu History Survey collected the unknown sect and, using the collections, identified as a thrips, *Sericothrips variabilis*. The s entists also used the international literat file at the Survey and found an Egypti paper which indicated that this particu thrips did not carry the bacterial dise Subsequently, in the laboratory, the s entists also confirmed that the thrips not carry the bacterium. Further, field vestigations showed that fields which h been sprayed actually demonstrated creased soybean growth. Within five da scientists from the Survey were on lo television advising the farmers that t thrips did not carry the disease a furthermore, that spraying should not cur.

A second example involved edible plan i.e., turnips and horseradish. Many these plants in southwestern Illinois show deformities during the growing season 1978. The USDA decided that these Il nois crops should be quarantined and n sold. Scientists from the Survey again us the collections and within two weeks h identified the insect causing the dama the imported crucifer weevil. The inves gation showed that the quarantine w unnecessary, and eventually a crop pr tection program was developed. On again, the collections resulted in an ide tification which was of considerable ec nomic value.

Adding to the collections is a continuo process. For example, on June 18, 198 one of the Survey scientists collected sunflower beetle in East Moline. This w the first recorded occurrence of this inse east of the Mississippi. Unfortunately, th insect is a major pest of commercial su flowers in Kansas. Again, the collectio provided not only the identity of the orga isms, but also established a perman record of its occurrence in Illinois.

The Illinois Natural History Survey the official depository of animal collectio within the State of Illinois. There a

searcher Don Webb checks a ecimen drawer in the Survey in-ct collection (Photo by Les Wood-m).



lmost 5,000,000 specimens in the insect ollection. It is the fifth largest in North merica, includes the largest collections in he United States of several groups of nsects, and contains over 3,000 type speci-nens. Type specimens are the actual speci-nens from which the original species de-cription was written.

Also among the Survey collections are 00,000 specimens of soybean arthropods, vhich represent the International Refer-nce Collection; 75,000 mollusks, the 12th argest collection in North America; 200,-)00 other invertebrates; 400,000 fishes, the 16th largest in North America and the argest collection of Mississippi River fishes n existence; and 11,000 amphibians and eptiles.

These collections are maintained in various ways. Insects and arthropods are stored usually as dry specimens on pins in special containers. On the other hand, fishes and some invertebrates are stored in alcohol.

Computers Aid in Fight

Economic entomologists conducting re-search on insect pests of alfalfa and other forage crops installed a minicomputer and word processor in their laboratory recently. This system allows for storage and retrieval of large amounts of data collected in the field and laboratory, historical type data, and references to published scientific re-search by colleagues throughout the world. Retrieval of information can be easily and quickly accomplished. Because of the sys-tem's communications capabilities, it is possible for researchers to use all the func-tions of the University's massive computer system. This, therefore, allows for extensive computer analysis of data. Researchers can also communicate with other researchers throughout the United States.

This type of communication is extremely valuable to Survey and Agricultural Ex-periment Station entomologists, W. O. Lamp and E. J. Armbrust, who are in-volved in a multi-state research project to develop comprehensive, unified, econom-ically and environmentally sound pest management systems for alfalfa. The ob-jective of these systems is to minimize losses to pests while optimizing the produc-tive longevity of alfalfa. Entomologists, weed scientists, and plant pathologists in Illinois, Kentucky, California, Wisconsin, and New York are working together and are being funded in part by the U.S. De-partment of Agriculture to accomplish these aims. The use of minicomputers and word processors has greatly assisted with the availability of data and its analysis by all researchers in this project.

Lamp and Armbrust have been working extensively with Southern Illinois Univer-sity weed scientist, George Kapusta, to determine an interaction of the potato leafhopper insect pest and weed pests found in alfalfa. Weekly samples of insects,

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weeds, and crop growth and yield for two years in alfalfa fields has produced large quantities of data that have been stored and analyzed through this minicomputer.

The potato leafhopper is a major insect pest in alfalfa and studies have shown that its presence may be reduced by the presence of weeds. The number of leafhoppers averaged 31 percent less in alfalfa where grass weeds were not controlled. Although the weeds do compete with the alfalfa, only the quality of the yield and not the quantity is reduced in this weedy alfalfa.

Several explanations for the effect of weeds on insects are presently being pursued. For example, the grass weeds are hosts for many other leafhopper and planthopper species. These noneconomic insects may compete with potato leafhoppers and reduce their populations.

Additional ways that weeds may influence insect pests are by serving as alternate hosts, confusing host-locating mechanisms, or altering host plant suitability. Once the cause of the observed interaction is known, techniques will be developed to manage the potato leafhopper using information on weed populations in alfalfa. If economic levels are lowered by such interactions, then fewer herbicides will be required for controlling weeds. In addition, fewer insecticides will be required for controlling leafhopper populations in weedy alfalfa. In general, the studies of wee insect interactions have resulted in t integration of control strategies for pests different disciplines, thus making the a falfa production system more efficient.

When these control strategies are intr duced at the grower level, pest populatio information pertaining to the various pe can be implemented and the proper co trol strategies can be disseminated throu the use of minicomputers. Communicatio and data storage and analysis at this lev of sophistication will make alfalfa pr duction more efficient with less harm the environment through the proper use pesticides. A production system of this ty could result in an increase in the longevi of the alfalfa crop.

Because alfalfa is a perennial legum with outstanding nitrogen-fixing capabi ities, it is of major importance in energ and soil conservation. Crop establishmen and long-term maintenance costs in term of energy and erosion can be greatly re duced through utilization of alfalfa. Th development of efficient strategies for pe population regulation and control ca further reduce the amount of energy re quired for production. For example, if th longevity of alfalfa was extended for onl one year, the increased production an energy savings would exceed $325,000,00 on a national scale.

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[N]ATURAL HISTORY [S]URVEY REPORTS

FEBRUARY 1983, NO. 224

[Sci]entists Unite to Provide Food

[T]he problem of providing food and nu[trit]ion for escalating populations in devel[opi]ng countries is enormous, with more [tha]n one billion people (about ¼ of the [wor]ld's population) known to be underfed [or] malnourished. These numbers and pro[por]tions may grow even faster than the [wo]rld population, which is projected to ex[cee]d six billion by the year 2000.

[A] major attack on this problem was [lau]nched at a recent international confer[enc]e in Manila attended by Survey Aquatic [Bio]logist D. Homer Buck. He participated [in] the workshop on Aquaculture and Inte[gra]ted Farming. Buck's working group [nu]mbered 13, including seven from Asia, [two] from Africa, one each from Sweden [an]d Australia, and Ed Lincoln of the Uni[ver]sity of Florida, who conducts research [on] the intensive production of microalgae [in] organically enriched systems.

Proceedings and reports emanating from [th]e conference and workshops will be avail[ab]le for reference at the Kinmundy field [sta]tion.

The meeting was called CHEMRAWN (Chemical Research Applied to World [N]eeds), with the more formal title of In[ter]national Conference on Chemistry and [W]orld Food Supplies: The New Frontiers. [Pr]incipal sponsors were the International [U]nion of Pure and Applied Chemistry and [th]e International Rice Research Institute.

The specified objectives of the confer[en]ce were (1) to identify and put into per[sp]ective those areas of research and devel[op]ment having the potential to significantly [in]crease food production and improve food [st]orage and processing; (2) to strengthen [sc]ientific research in developing nations, particularly in those fields which require professional competence and initiative without excessive capital and human resources; and (3) to accelerate implementation of research priorities and objectives by fostering cooperation among governments, industries, and universities.

The formal scientific papers were presented by a selection of distinguished international scholars, including five Nobel Laureates. Papers were presented in seven separate sessions: Soil and Crop Management for Efficient Use of Water and Nutrients, Integrated Approaches to Pest Management, The Role of Chemistry and Biochemistry in Improving Animal Production Systems, Contributions of Chemistry and Biochemistry to Developing New and Improved Food Sources, Chemistry and Biochemistry in the Processing and Storage of Food, Chemistry in the Assessment and Control of the Food Supply, and The Forward Edge.

As anticipated, the most exciting and imaginative subjects were discussed in the last session, The Forward Edge. Subjects addressed here included potentials and prospects in genetic engineering, wide crosses in plants, new strategies and methods for selection and utilization of germplasm, the role of growth regulators and hormones in enhancing food production, the potentials for increasing rates of nitrogen fixation, and for improving the efficiency of photosynthesis.

The second phase of activities, the post-conference workshops, were convened in the impressive facilities of the International Rice Research Institute adjoining the campus of the University of Philippines at Los Banos. The activities at Los Banos were

funded by the US Agency for International Development, and were organized by the US National Academy of Sciences, more specifically by the Board on Science and Technology for International Development (BOSTID), which was responsible for selecting the participants in four separate workshops:

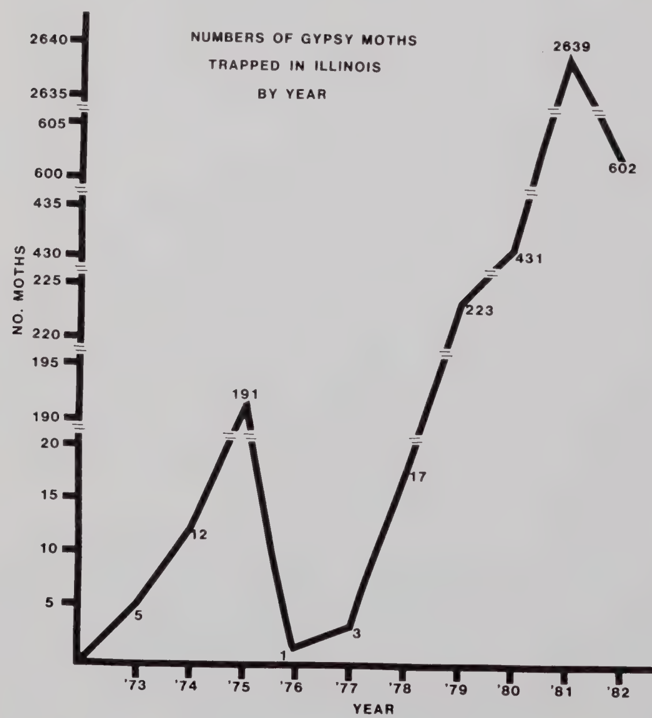
(1) Soil Fertility and Plant Nutrition
(2) Plant Growth Regulators and Plant-pest Relationship
(3) Food Science and Technology
(4) Aquaculture and Integrated Farming Systems.

The responsibilities of the workshop participants were to combine the information presented at the conference with their own knowledge and observations in identifying those research areas having the highest potential for improving food supplies in developing countries, and which should receive highest priority for funding. Where possible and appropriate, cooperative studies will be conducted jointly in a developed and a developing country.

The Gypsy Moth in Illinois

The gypsy moth, a tremendously destructive tree pest, has now reached Illinois from the northeastern United States. The m is often unintentionally transported to nois by families moving to Illinois from fested areas in the east. The Illinois partment of Agriculture is responsible monitoring the spread of this insect the use of gypsy moth sex pheromone tr for the detection of adult male moths. nois Department of Agriculture person have traps in all counties of Illinois.

The Illinois Natural History Sur team of scientists and technicians, in co eration with the Illinois Department Agriculture, is using trapping data to sess the future probability of outbreaks the gypsy moth. A high male moth t catch in a particular area indicates t larvae of the gypsy moth have been feed in that area for one or more years. Infes areas are scouted extensively for gy moth egg masses during the autumn a winter months by Illinois Department Agriculture's staff and when egg mas are found they are carefully collected a either destroyed or transported to Natural History Survey's quarantine lal ratory at Champaign. There the eggs examined for viability, parasites, and c ease organisms. Only two percent of t eggs in egg masses collected in March 19



Graph shows rapid increase in nu ber of gypsy moths in Illinois; d in summer of 1982 was caused severe winter weather of 1981-19

ere viable, and the high egg mortality as attributed to the adverse winter cliate of 1981-1982.

The first detection of gypsy moths in Illiois occurred in 1973 when two moths ere captured in Cook County and one ich in Rock Island, Sangamon, and Will ounties. The records on moth catches in linois vary considerably from year to year ue to control programs, climatic conditions, number of traps used by the State epartment of Agriculture and the status f the gypsy moth population in the northastern portion of the United States. Seere gypsy moth outbreaks in eastern states icrease the chances of gypsy moth egg iasses and pupae being unintentionally ransported into Illinois. Cooperative studes with the Illinois Department of Agriulture will continue, since their help is ital to our understanding of the gypsy ioth problem in the state.

'ossible Effects of Reduced Tillage n Corn on a Black Cutworm Parasitoid

The black cutworm, *Agrotis ipsilon* Hufiagel, is well known to Survey entomoloists as a major pest of seedling corn in the Aidwest. Adult moths migrate into Illinois n the early spring, and lay their eggs on veeds and crop residues within or borderng fields before corn is planted. Young arvae feed on these plants till corn seedings emerge; they will then start feeding n corn leaves, particularly if planting and ultivation have removed all other vegeation. Older cutworms cut corn seedlings it the base, and in sufficient numbers can ause serious economic damage.

Reduced tillage in corn is currently beng encouraged to conserve energy and derease soil erosion. These positive effects nust be weighed against trade-offs such as ncreased insect and weed problems. Certain insects, such as the black cutworm, are expected to cause economic damage nore frequently in reduced-tillage corn because of increased crop residues and weediness in fields before planting. Survey researcher Mike Foster suggests that it is important to determine the effects of reduced tillage on natural enemies of corn pests as well as the pests themselves. Predators and parasitoids do not control corn pests, but are important because their activity decreases the frequency and severity of damage. As a graduate student working with Bill Ruesink, Survey entomologist, Foster has been looking at the effects of weeds common in reduced-tillage fields on a major black cutworm parasitoid, *Meteorus leviventris* Wesmael.

This parasitic braconid wasp attacks cutworms just old enough to cut corn seedlings, and the development of its young inside the host kills cutworms prematurely. Consequently, parasitized cutworms cut fewer corn seedlings. Foster learned from laboratory observations that *Meteorus* females live longer, attack more cutworm hosts, and produce more offspring if they are provided with an energy source such as honey water. In addition, many species of parasitic wasps and flies are known to benefit from floral nectar both in natural habitats and in various crops. Armed with this information, Foster hypothesized that some of the flowering weeds found in reduced-tillage corn provide nectar which benefits *Meteorus* and increases its effectiveness as a black cutworm parasitoid.

In the fall of 1981, laboratory experiments were conducted to determine the effects of five flowering weeds on adult female *Meteorus*. Three of these weeds, chickweed, mustard, and shepherd's purse, are common and flowering in reduced-tillage fields before planting. The other two species, wild parsnip and lady's thumb smartweed, are common and flowering in field borders or nearby uncultivated areas soon after planting. These experiments demonstrated increased longevity, repro-

Actual size of *Meteorus leviventris* female above is 3½ millimeters (Photo by Les Woodrum, Survey Photographer).

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duction, and more hosts attacked by wasps provided with these flowers, in comparison to starved female *Meteorus*.

In the spring of 1982, a field experiment was set up to determine if flowering weeds would result in increased parasitism and decreased cutting damage under seminatural conditions. One-meter-square plots of seedling corn enclosed in field cages were subjected to three treatments: 20 cutworms, cutworms and 10 female wasps, or cutworms, wasps, and flowering weeds accessible only to the wasps. The results suggest increased parasitism and decreased cutting damage in the presence of flowering weeds.

A greenhouse experiment was conducted in the fall of 1982 to determine how increased wasp lifespan, an effect on individuals, translates into increased parasitism, an effect operating at the population level. Two variables were manipulated: the presence of flowering chickweed and the initial ratio of wasps to cutworms. Foster hypothesized that nectar, by increasing wasp lifespan, would increase the average wasp-to-cutworm ratio over several days and consequently result in greater parasitism. Flowers did indeed increase the average wasp-to-cutworm ratio over several days, but this resulted in greater parasitism only if the initial wasp-to-cutworm ratio was low. These results imply that an adequate nectar supply will have the greatest impact on field rates of parasitis[m] when spring populations of *Meteorus* a[re] low.

The experiments described demonstrat[e] that *Meteorus* benefits from flowerin[g] weeds common in reduced-tillage cor[n]. Two other major parasitoids of the blac[k] cutworm are *Bonnetia comta,* a tachini[d] fly, and *Microplitis* (two species), a braconid wasp. Both insects are known to benefit from a sugar source and these flowerin[g] weeds may also be beneficial to them.

Because reduced tillage affects both cutworms and their natural enemies, its effec[t] on the risk of cutworm damage is likely t[o] be quite complex. For example, if natura[l] enemies are not considered at all, on[e] would predict an increased risk of cutworm damage with moderate levels of weediness before planting. However, if there were sufficiently high levels of *Meteorus* in the early spring and they were benefited sufficiently by a nectar supply, this might offset the increased levels of cutworms. Foster is currently developing a computer model to determine by simulation the effects of weed-*Meteorus* and weed-cutworm interactions on parasitism and cutting damage. This model will allow researchers to distinguish situations in which prepiant weediness can be tolerated from those in which weediness will increase the risk of cutworm damage.

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NATURAL HISTORY SURVEY REPORTS

NATURAL HISTORY SURVEY

MARCH [illegible]

ansmitters Designed for Condor

A tiny, solar transmitter designed and ıde by W. W. Cochran, Jr., associate ldlife specialist at the Survey, has enabled entists to tag and track a California ndor by plane during the past few weeks. chran is in California working on an tomatic receiver that will eliminate the ed for cars and planes in tracking the d.

The first free-flying California condor ıs captured last fall near Ventura. Dr. el Snyder, condor research biologist for e U.S. Fish and Wildlife Service, fired e cannon-net over the condor while it ıs feeding on a calf carcass. It resisted enuously, biting the hands of its captors, ıt displayed no signs of stress during the itial examination.

The bird was held at the San Diego Zoo hile blood samples were taken and anazed to determine its sex. It proved to be a -pound male. The condor was fitted with o solar-powered transmitters and then leased. It has been followed by an airane most of the time since the release.

. Noel Snyder, U.S. Fish and Wildlife Service, taches Cochran transmitter to condor as his assisnts hold bird (Photo by Helen Snyder, U.S. Fish and ildlife Service).

The California Fish and Game Commission authorized the trapping of immature condors late in 1982. However, only two birds can be taken into captivity under the permit for a year. Trapping has now been resumed to capture a female of the species.

Begun late in 1979, the purpose of the program is to identify factors causing the continued decline of the wild California condor population, and at the same time, to breed the birds in captivity for eventual release in the wild.

The California condor research project is a cooperative effort among the Fish and Wildlife Service, the National Audubon Society, the California Fish and Game Commission, the Forest Service, the Bureau of Land Management, and the Illinois Natural History Survey.

For at least 20 years, Cochran has been designing and making various kinds of transmitters and receivers for tracking all kinds of wildlife including small birds, ducks, geese, rabbits, deer, and even fish.

Wildlife specialists agree that more meaningful interpretations of the lives of animals will result from finding out what an animal is doing at a particular place at a particular time, and how its pattern of activities fits into its year-round needs for successful survival and reproduction.

The Aster Leafhopper: A New Vector of *Spiroplasma citri*

In 1981 University of Illinois plant pathologists and Survey entomologists reported the discovery that *Spiroplasma citri* is the causal agent of brittle root disease of horseradish in Illinois. *S. citri*, well known for its association with a severe disease of citrus in the southwestern United States, is

a small, helical, bacterialike organism found in the phloem of diseased plants and transmitted by leafhopper vectors. One of these vectors, the beet leafhopper (*Circulifer tenellus*), was shown to transmit the spiroplasma from brittle root-diseased horseradish to healthy horseradish plants in laboratory tests.

While the beet leafhopper was collected in horseradish fields during several brittle root epidemics, it was not found during the 1975 outbreak despite intensive sampling of horseradish fields. This discrepancy led Survey entomologists Karen O'Hayer, Gerald Schultz, and Catherine Eastman and University plant pathologists Jacqueline Fletcher and Robert Goodman to investigate other leafhopper species as possible vectors of *S. citri* in Illinois. The aster leafhopper, *Macrosteles fascifrons,* was of special interest because it is already known as a major vector of several other plant pathogenic organisms and because it is collected routinely in Illinois horseradish fields, sometimes in large numbers.

An understanding of the type of pathogen-vector relationship involved was essential in determining the best means of testing the aster leafhopper as a potential vector of *S. citri.* This spiroplasma is one of several pathogens which are transmitted in a circulative-propagative manner. After being taken up by the insect during feeding, the pathogen must penetrate the gut wall and enter the circulatory system. From there it moves through the insect's body,

Aster plant on left was exposed to infected leafhoppers and shows stunting and chlorosis typical of *S. citri* infection. Aster plant in center was exposed to control leafhoppers, and the aster plant on the right was not exposed to leafhoppers (Photo by Les Woodrum, Survey photographer).

infecting and multiplying in various tiss[u] including the salivary glands. This wh[ole] process may take several days or we[eks]. The pathogen then can be introduc[ed], along with the saliva, into the phloem o[f a] host plant during feeding.

The first step in evaluating the as[ter] leafhopper as a potential vector of *S. c[itri]* was to determine if this insect could tra[ns]mit the pathogen after being injected w[ith] a suspension of cultured spiroplasmas. T[he] microinjection technique involves the [in]troduction of a large quantity of the pa[th]ogen directly into the leafhopper's circ[u]latory system, thereby increasing the chan[ce] of subsequent transmission. Aster leafho[p]per adults were injected with a hor[se]radish isolate of *S. citri* and were caged [on] barley plants (a preferred host) for 14 da[ys] to allow time for the pathogen to circula[te] and multiply within the leafhoppers. Th[en] the leafhoppers were confined on aster a[nd] horseradish test plants for 7-day feedi[ng] periods. In the combined results of two e[x]periments, the leafhoppers transmitted [*S.*] *citri* to 27 of 41 aster (66 percent) and [11] of 46 horseradish plants (24 percent).

The success of the microinjection expe[r]iments indicated that *S. citri* could multip[ly] in the aster leafhopper and could be intr[o]duced into plants during feeding. A tr[ue] test of an insect's potential as a vecto[r], however, is whether or not it can acqui[re] enough of the pathogen naturally by fee[d]ing on infected plants to permit subseque[nt] transmission of the organism to health[y] plants. Sometimes the digestive tract of a[n] insect species acts as a barrier, preventin[g] passage of a pathogen into the blood. I[n] separate tests aster leafhoppers were co[n]fined on *S. citri*-infected plants (aste[r], turnip, or bassicaceous weed yellow rocket) for 7-14 days. After another 7-14 days o[n] barley, leafhoppers were caged on te[st] plants (aster, horseradish, or turnip) fo[r] 3-7-day feeding periods. In combined re[]sults from four experiments, leafhoppe[rs] transmitted *S. citri* to 9 of 128 aster ([] percent), 1 of 69 horseradish (1 percent), and 3 of 54 turnip (6 percent) plants.

Infected aster and turnip plants devel[]oped chlorosis and stunting of young leave[s] and reduced overall plant growth. Infecte[d] horseradish plants were stunted and chlor

ic with reduced secondary root growth d phloem discoloration characteristic of ittle root disease. All control plants ex- osed to leafhoppers fed previously only on ealthy plants remained free of symptoms. o confirm these results, attempts were ade to isolate spiroplasmas from plant ssues; spiroplasmas were present only in ants with the described symptoms.

The discovery that the aster leafhopper n transmit *S. citri* after acquiring it by eding on diseased plants strongly suggests at this species may be a natural vector of e spiroplasma and, thus, may be involved the epidemiology of brittle root disease. he transmission frequencies in these tests ere low, but this does not lessen the otential importance of the aster leafhop- er as a vector of *S. citri*. Inefficient trans- ission could be compensated for by the rge populations of this insect which often ccur in the Midwest. The plant host anges of both *S. citri* and the aster leaf- opper include species in the families steraceae, Violaceae, Fabaceae, Brassi- aceae, Rosaceaem, Ranunculaceae, Mal- aceae, Caryophyllaceae, and Liliaceae. herefore, the aster leafhopper may be in- olved in the spread of *S. citri* to other sceptible plants in addition to horse- adish. The potential importance of this nsect as a vector of *S. citri* is enhanced urther by the fact that of the four known ectors of spiroplasma, the aster leafhopper as the most extensive geographical range, hich includes Mexico, the continental Inited States, and most of Canada.

quaculture May Become ew Illinois Resource

Because Illinois and nine other states roduce about 75 percent of the country's vaste products, Stephen Waite, aquatic iologist at the Survey, believes that this vaste may turn out to be one of the state's nost priceless resources.

Waite, who hopes to initiate an aqua- ulture program in Illinois, says even hough the state is well known for its land- ased agriculture, it has no large scale quaculture at present. Aquaculture is he cultivation of aquatic plants and ani- nals for human consumption. With pop- ulations increasing and good farmland

Swine are confined to cages over water at Kinmundy where aquaculture project was begun in 1975 (Photo by Les Woodrum, Survey photographer).

reaching its maximum productivity, more people are exploring ways to use aquacul- ture to meet the rising demand for food.

D. Homer Buck, another Survey re- searcher, has been working since 1975 on small-scale aquaculture systems using swine manure to culture fish. Swine, fed com- mercial chow, produce a great deal of manure. The manure is washed into a pond set below the hog pens where it serves as food for those lower in the food chain, specifically plankton and algae. These microscopic organisms in turn serve as food for fish such as carp and fresh- water shrimp. One of the problems sci- entists had to work out was how much manure should be added to the system. Manure releases ammonia which is quickly utilized by algae. The algae bloom, then die. The decomposition process uses large amounts of oxygen, so much so that the fish can suffocate.

Waite has spent the last year looking for ways to overcome the problem of excess ammonia in the systems. He found what he was looking for in the Chinese water chest- nut because it is an aquatic plant that re- quires its nitrogen in the form of ammonia. Water chestnuts are a popular food for human consumption and can also provide food for fish. The production of aquatic plants that serve this double function can be extremely valuable with regard to the overall economics of the system.

Waite suggests that commercial-sized sys- tems be set up to produce crops year-round for the commercial market. The Survey is

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planning to design and build several units to demonstrate that aquaculture is economically feasible from a commercial standpoint in Illinois.

Waite says that farmland is so valuable in Illinois that good lands should not be converted to ponds, but lands can be found that are less productive. Because of the relatively short growing season outdoors, indoor systems under covered greenhouses could be used. Solar greenhouses and other specifically designed buildings could be used so that something could be planted and something harvested every month.

Indoor systems would have many advantages. It would be easier to eliminate mortality due to predators, to prevent a[nd] control disease vectors, and avoid contam[]ination from industrial and agricultu[ral] toxicants.

Land, water, and other resources such [as] waste heat could be used more efficien[tly,] providing greater production per unit spa[ce] and flexibility for siting near sources of r[e]cyclable waste.

According to Waite, the net benefit [of] these advantages would be maximum yea[r-]round production on a highly predictab[le] basis — a big point to commercial marke[ts] — on a scale that justifies the operation [of] the systems.

New Publications List Is Being Processed

A much larger, more comprehensive Publications List is being edited and placed on the word-processor for easier future updating. The new material and method has made the production more time consuming. The new Publications List will be available in early summer. Requests are being held on file and will be filled when the publication becomes available.

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DR. PAUL G. RISSER, CHIEF, ILLINOIS NATURAL HISTORY SURVEY, DEPARTMENT OF ENERGY AND NATURAL RESOURCES
NATURAL RESOURCES BUILDING, 607 E. PEABODY, CHAMPAIGN, ILLINOIS 61820

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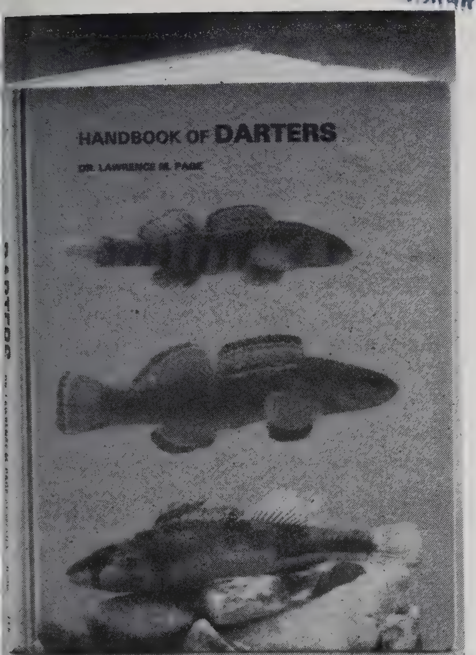


ok on darters was written by Survey researcher M. Page (Photo by Les Woodrum, Survey photographer).

iandbook of *Darters* Published

About 150 (20 percent) of the 800 pecies of freshwater fishes in North Amera north of Mexico are darters, small relaves of the walleye, sauger, and yellow erch. One species, the snail darter, is well nown because of the recent highly publiized conflict between retention of its abitat in eastern Tennessee and compleon of Tellico Dam. Other species are unnown generally to most persons, but are mong our most colorful and interesting shes. David Starr Jordan, a famous ichyologist, referred to darters as "the most ascinating, vivacious, and individual of ll river fishes."

A just-published book, *Handbook of Darters,* authored by Survey scientist L. M. Page, is now available from T.F.H. Publications, Inc., Neptune City, NJ 07753. Page discusses the identity, relationships, distribution, and natural history of the 129 named species and comments on most of the recognized but as yet unnamed species. Included in the book are 308 color photos, 89 distribution maps, and summary chapters on the ecology, evolution, and zoogeography of darters.

Darters are found in the Mississippi River, Great Lakes, Hudson Bay, Atlantic Slope, and Gulf of Mexico drainages, and one species lives in a Pacific drainage of Mexico. Most (87) species occupy the Mississippi River system. The largest geographic range is that of the logperch which ranges from Hudson Bay to the Gulf of Mexico and from Saskatchewan to eastern Quebec. The smallest range is that of the Maryland darter, which is confined to one riffle in Maryland.

Most darters reach a maximum length of less than 100 mm (4 inches). At a maximum recorded length of almost 200 mm (8 inches), the freckled darter, an inhabitant of Gulf slope drainages, is the giant among the group. The smallest, at 45 mm (1¾ inches), is the fountain darter, a species occurring in only one spring and its effluent in southern Texas.

Most species feed on microcrustaceans (copepods, ostracods, and cladocerans) as young and on immature aquatic insects as adults. A few specialize on snails and scuds (amphipods). Most spawn in spring, although at southern latitudes some may spawn for extended periods, and species occupying constant-temperature springs

may spawn the year round. Maximum life spans vary from 1½ to 4½ years, with large species living longer than small species.

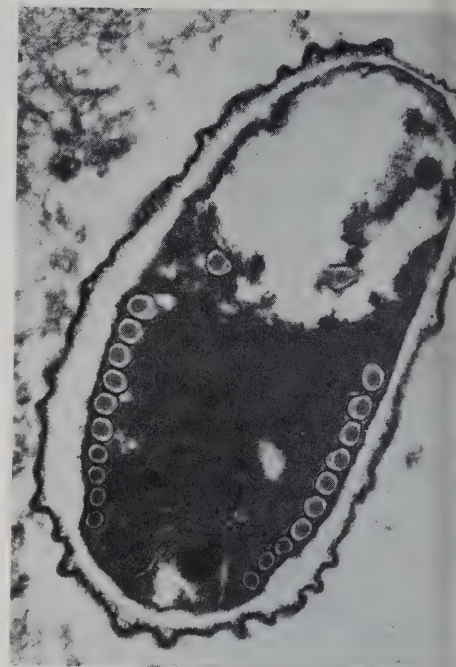
Darters have reached their high level of diversity by occupying a wide variety of habitats. Many species are restricted to major physiographic regions; as examples, the swamp darter is found almost solely on the Coastal Plain, and the longhead darter is restricted to the Appalachian highlands. Other major determinants of distribution are habitat characteristics which may or may not correspond to physiographic boundaries, and competition with closely related species. The stringent requirements of many species make them vulnerable to extirpation, but also make them excellent indicators of the environmental health of streams and lakes. Most species occupy flowing habitats of streams and are unable to live in artificial impoundments. Many populations have been eliminated because of excessive deposition of silt on their former feeding and spawning grounds. Illinois historically had 27 species of darters; now it has only 23 species, several of which are rapidly becoming less common.

Publication of the *Handbook of Darters* follows over 150 years of research (the first species was described in 1818). Page has been studying darters since 1967. A substantial portion of recent research, especially life-history and systematic studies has been done at the Survey. Much remains to be studied, and the *Handbook* serves to elucidate needed areas of research as much as it summarizes existing information.

Small Pathogens of Small Animals

The Collembola, or springtails, are a group of minute animals that occur in damp soil, leaf litter, under bark, in decaying logs, in fungi, and on the surface of some freshwater pools. There are over 2,000 species of Collembola worldwide. They are quite common and often occur in great numbers, but because Collembola are so small, usually less than 4 mm long, they usually go unnoticed. This is unfortunate for persons having an interest in biology because Collembola have many fascinating characteristics.

Especially interesting is the structure that gives Collembola the name "spring-



Cross section of a spore of a microsporidian spe[…] found infecting a Collembola. The actual size i[…] microns long (Photo by Joseph Maddox).

tails." This is a small forked structure [...] the ventral side of the fourth abdomi[...] segment. At rest this structure is fold[...] forward under the abdomen and held [...] place by a clasplike structure on the thi[...] abdominal segment. When the clasp [...]leases the forked structure, it moves p[...]teriorly with force, pushes the Collembo[...] off its perch and propels it forward. [...] Collembola only 5 mm in length can jun[...] 80-90 mm. Some species of Collembo[...] may occasionally cause damage to plants [...] gardens, greenhouses, or mushroom cella[...] but they are probably most important [...] the transformation of organic material [...] upper layers of soil.

Until recently microsporidian parasit[...] common in most groups of insects, h[...] never been reported from Collembola. T[...] microsporidia are a group of tiny anima[...] having infectious spores which are typical[...] between 3-10 microns in length. They a[...] obligate parasites, primarily of invert[...]brates. Survey researcher and Collembol[...] taxonomist, J. A. Mari Mutt several yea[...] ago observed that a few Collembola spec[...]mens in the extensive Natural History Su[...]vey collection of Collembola had thousan[...]

small refractive oval bodies in muscle ıd fat body tissue. In cooperation with sect pathologists, J. V. Maddox and V. -unjes, Mari Mutt removed the Collem- ɔla containing these small oval bodies om the glass slides on which they were ounted. They were then processed for ansmission electron microscopy, sectioned, ıd viewed under an electron microscope. his is the first time microsporidia have een recovered from mounted museum ɔecimens.

Microsporidian infections were found in ve different species of Collembola in the NHS collection. Two specimens were col- ected in Algeria, the other three in France, ortugal, and the Dominican Republic. efore the publication of this study, micro- ɔoridia were also reported from seven ɔecies of Collembola, all collected in the ederal Republic of Germany. The discov- ry of seven species of microsporidia-in- ected Collembola in the Federal Republic f Germany and five infected Collembola ı the INHS museum, collected from di- erse locations, suggests a rich source of ndescribed microsporidia in the Collem- ola.

This is especially interesting to Micro- poridia and Collembola taxonomists as everal of the microsporidia found in Collembola are quite unusual and the Col- embola, belonging to the sub-class Aptery- gota, comprise a primitive group of animals ong isolated phylogenetically from other nsects. In fact, many systematists think the Collembola are a separate group between he Insecta and Myriapoda. It will be inter- esting to compare microsporidia from Col- embola with microsporidia from the Myr- apod classes according to researchers at the Survey.

Kentucky Cave Shrimp

With more than 250 species of animals recorded, the Flint-Mammoth Cave System in Kentucky is believed to be the most bio- logically diverse cave in the world. At least 50 of the species are troglobites or troglo- philes. A troglobite is an organism which to survive must spend its entire life in a cave; a troglophile is an organism which may, but is not obligated to, spend its entire life in a cave.

The Mammoth Cave region has such a high diversity of life because of the diver- sity of cave types, habitats, food types, and geographic sources of the fauna. In this "ecological theater," the evolution has in- volved both local species and those that have migrated in from three adjacent cave regions. Three species of cave fishes come from the three regions and co-occur only in the base level stream passages of Mam- moth Cave. The Kentucky Cave Shrimp, in contrast, evolved locally and is unique to the Mammoth Cave System.

The shrimp have evolved a life cycle which requires their isolation in pools near base-level rivers. As the annual winter floods recede, the shrimp, which probably lives only one or two years, seeks isolated pools above the low-water level. The or- ganic veneer, deposited by winter floods, provides a propitious habitat for micro- organisms, which are the main food of the shrimp. A favorable food supply as well as protection from predation allow the shrimp to mature during the summer, and allow the newly hatched young to develop suffi- ciently before the annual winter floods begin. The shrimp's small population size, limited distribution, and specialized re- quirements make it extremely vulnerable to habitat disturbances. They are, therefore, considered to be an indicator species of the health of the entire aquatic ecosystem in the base level rivers of Mammoth Cave.

In 1901, William Perry Hay first dis- covered the shrimp in a series of small pools, now known as the Shrimp Pools, in Roaring River of Mammoth Cave. In

Kentucky Cave Shrimp is rare and difficult to locate (Photo by Ed Lisowski).

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1928, during their expedition to caves of North America, the prominent European cave biologists, Candido Bolivar and Rene Jeannel found shrimp in a pool near Echo River and, in 1929, Leonard Giovanolli found shrimp in isolated pools associated with nearby Styx River. Biologists did very little in the cave from 1930 to 1950, but during the 1950's and until 1967, the Kentucky Cave Shrimp usually could be found in the Shrimp Pools as well as in small pools near the Golden Triangle, a base level stream several miles from Roaring River but still part of Mammoth Cave. Since the shrimp were not seen again during the subsequent 12 years, they were feared extinct.

Disturbances of the aquatic habitats in Mammoth Cave may have caused the decline in populations of the shrimp from these historic localities. Pollution, both from leaking sewage lagoons within Mammoth Cave National Park and from sources outside the park have had a negative impact on cave rivers. Dams on the Green River have modified the habitat and altered the flooding cycles of the cave rivers. The pool behind one dam extended into some of the cave rivers, which permanently flooded many of the once seasonally isolated pools, increased siltation, and disrupted nutrient flow into the cave. All three dams altered the flooding cycles by decreasing the intensity of winter flooding and increasing the frequency of summer flooding. Th may have impacted the shrimp by disrup ing its reproductive cycle, which is synchr nized with winter flooding, and by redu ing the feeding time in quiet pools for bo adults and newly hatched young.

Between May 1979 and September 198 Survey scientist Ed Lisowski searched on monthly basis for shrimp at their histo ically known localities. After finding o dead shrimp in the Shrimp Pools in Se tember 1979, he arranged for cave scu divers to look for shrimp in the deep poo of Roaring and Echo rivers and in su merged cave passages. During four div between October 1980 and January 198 they found a total of 17 shrimp, and i January 1981, Lisowski found three shrim in the Golden Triangle.

These data demonstrate that, althoug not extinct, the Kentucky Cave Shrimp rare. The U.S. Fish and Wildlife Servic has accepted a petition to begin the proce of listing the shrimp as a federally en dangered species, and the National Par Service funded a 2-year study of th shrimp's biology and distribution so tha the Service could develop a managemen program to conserve the shrimp. Lisowsk has volunteered his time to assist with th study. The USFWS has delayed the fina determination of the status of the shrim until the completion of the study in Octo ber 1983.

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SURVEY REPORTS

e Declining Grassland Birds

Until at least 1959, populations of grass-
.d species of birds in Illinois were re-
rkably preserved, considering that the
ginal prairie was all but gone and had
en for many decades. It was true that the
irp-tailed grouse had been extirpated,
it the greater prairie chicken was greatly
luced, and that the Eskimo curlew — a
ce abundant transient of the Illinois
airie — was near extinction, but song
ds of the prairie were surviving. They
d adapted well to the mixed agricultural
actices of the day.

Censuses in 1957 and 1958 across the
rth, middle, and south of Illinois by Drs.
an and Richard Graber of the Survey's
ildlife Research Section showed that
eeding populations of the prairie species
song birds were nearly as numerous (or
en more numerous in some cases) as in
06-1909 when the first cross-country
ansect censuses were made for the Illinois
atural History Survey by Alfred O. Gross
d Howard Ray. For example, there were
out 4,000,000 birds of the two meadow-
rk species in Illinois in 1906-1909 and
800,000 in 1957-1958, about 1,200,000
bolinks in 1906-1909 and 1,900,000 in
957-1958; and about 1,700,000 dickcissels
1906-1909, and 3,400,000 in 1957-1958.
Iayfields and pasturelands were providing
dequate habitat for these and other grass-
nd species in Illinois.

After 1960, farming practices changed
apidly with increasing specialization and
mphasis on the production of corn and
ybeans. The managed grasslands that had
upported populations of prairie birds
ropped precipitously in acreage — as much

Male bobolink (left) and female bobolink in grassland nesting habitat (Photos by Richard and Jean Graber).

as 50 percent per decade, and it was clear that grassland species of birds were declining. Populations of birds cannot increase their densities in a dwindling area of habitat, but if such an ability existed, Illinois provided a supreme test case in the 1960's and 1970's. Censuses were needed to see precisely what was happening. When the 70th anniversary of the first series of censuses arrived, the Grabers were completing a study of heron populations in the state, but in 1978 and 1979 they censused as much grassland habitat during the nesting season as they could cover in the time available. It was difficult to find enough grassland to census, but ultimately about 450 acres were censused in northern and central Illinois. The results were surprising, for population densities of almost every grassland species had fallen 80-90 percent below those of 1957-1958. Combining density loss *and* habitat loss, total population loss among grassland species of birds has been catastrophic. Total losses for representative grassland species are shown in the table. Because southern Illinois is south of the range of some prairie species, the data refer to northern and central Illinois only.

Species	Population Loss Since 1957-1958 (%)
Upland Sandpiper	—92
Bobolink	—97
Meadowlarks (2 species)	—84
Dickcissel	—96
Grasshopper Sparrow	—96
Savannah Sparrow	—98
Henslow's Sparrow	—94

When we consider that such great changes occurred in about 20 years — only a brief moment in the history of a wild population — the figures are alarming. A large decline was expected because of habitat loss, but why did the densities decline? Have qualitative changes occurred in the habitats? Or do the problems of the grassland birds lie along the migration routes, or on the winter ranges of the various species? The group includes species which winter south of the equator in South America (Bartramian sandpiper and bobolink), in Central America (dickcissel), and along the Gulf coast of the United States and Mexico (grasshopper and savannah sparrows). Are there problems for the species in all these places and in Illinois too?

The answers require intensive field work not yet begun, but, obviously, no population can endure such losses for long.

Pesticide Biodegradation: Too Much of a Good Thing?

Over the last 25 years soil insecticides have become an important tool in the control of soil insect pests. Almost 50 percent of the corn acreage in Illinois (about 6 million acres) is treated at planting time with an insecticide. In general, these tools have been very effective in reducing root damage caused by heavy infestations of corn rootworms in fields planted to corn in consecutive growing seasons. However, during this period a few of the insecticides have performed poorly or inconsistently. It would be a simple matter to switch to more effective chemicals, but the rate of introduction of new insecticides has slowed considerably. The arsenal of soil insecticides is becoming more limited, especially when one considers that the currently used products generally lack chemical diversity.

Within the last 15 years a grad
change has occurred in the kinds of s
insecticides used. In the 1950's and 196
the chlorinated cyclodienes (i.e., aldr
heptachlor, and chlordane) were co
monly used for soil insect control throug
out the Midwest. The use of these che
icals was eventually discouraged and th
suspended because they persisted in t
environment for excessively long times a
tended to accumulate in biological tissu
The organophosphate and carbamate i
secticides slowly replaced the cyclodien
These chemicals degraded quickly in t
environment and were shown to have a lo
tendency for bioconcentration. On the oth
hand, the organophosphates and carb
mates are generally less active again
insects in soil than the chlorinated cycl
dienes. Thus, changing chemical usage pa
terns have demanded extensive study of th
principles affecting the environmental ar
toxicological behavior of soil insecticide
One research area gaining more attentio
centers on performance problems of sc
pesticides.

Survey entomologist and insecticide tox
cologist, Allan Felsot, has been investiga
ing the cause of soil insecticide perfo
mance problems. Entomologists are quic
to suspect the development of insecticid
resistance when an insecticide perform
poorly. Corn rootworm beetles develope
resistance to the chlorinated cyclodienes i
the 1960's, but monitoring of differen
rootworm beetle populations in Illino
during the last three summers failed t
show any relationship between insect sus
ceptibility to carbofuran and control effi
cacy. Research from other states also indi
cated that the susceptibility of the corn
rootworm to various insecticides had no
changed significantly over the last decade
These results led to a second explanation
for insecticide performance problems based
on the potential of the currently used prod
ucts to degrade rapidly in soil. An effective
soil insecticide must be present at a toxic
concentration from 1 to 2 months following
application because the corn rootworm
does not hatch and start feeding in Illinois
until early June. In several soils that were
collected from northwest Illinois, carbo-
furan insecticide completely degraded with-

30 days. These soils were collected from ds where the chemical had been used several consecutive years before a con- l failure was noted. Further studies in- ated that the insecticide was being de- ided by microorganisms which had oliferated in this soil. Apparently, some oups of soil microorganisms use added sticides as nutrient or energy sources and ereby greatly expand their populations. hen a soil containing these conditioned crobial populations is retreated, the sticide is degraded at a very rapid rate d its concentration falls below the level cessary to kill the insects. At present, it not known which soil types contain icroorganisms capable of adapting to the sticide, nor exactly which pesticides are sceptible to this rapid biodegradation. irther studies are being conducted to aracterize this phenomenon and its im- ications for the chemical control of the rn rootworm in the Corn Belt.

ransplanting New Trees

Transplanting is a major operation from hich most plants recover slowly, even hen growing conditions are ideal. Nor- ally, a tree maintains a certain balance etween its top and root system. Water and itrients are taken in through the roots to ipply the plant with elements necessary ir food production in the leaves. The ansplanting operation, regardless of how irefully it is performed, is destructive to a rge portion of the absorbing root area. Ince the roots are severed during the dig- ing operation, the tree is in varying de- rees of water stress until new roots are egenerated and able to absorb the neces- iry water and nutrients from the soil.

In studies conducted in the Survey's ex- erimental tree nursery, up to 98 percent f the root system of trees 3-6 inches in iameter is removed in the transplanting peration when the soil balls are as much s 4 feet in diameter. Smaller soil balls will ontain even fewer original roots. The tudy also showed that the density of fine oots was greatest in the top 4 inches of oil and that the large main structural roots vere predominantly located at the soil lepth of 5-13 inches, with limited develop- nent in the top 4 inches and decreasing development at depths below 13 inches. In general, most tree species tending to be more deeply rooted are not as tolerant to heavy clay soils having seasonal high water tables, a condition which often exists in many urban soils. These field studies gave substantial evidence of the shallowness and importance of the development of the fine absorbing root system of transplanted trees.

Careful preparation is made for transplanting a tree (Photo by Eugene Himelick).

In lawn areas, it has been shown that competition from grass is an important factor limiting the development of the shallow tree roots. This evidence supports previous work in which mulching the soil around trees increases the fine root devel- opment by reducing or eliminating grass competition and by helping maintain ade- quate soil moisture and aeration in the upper soil layer.

A guide to the ease of moving various tree species and the best season to trans- plant them was recently prepared and is available upon request. Those tree species difficult to transplant should receive the utmost care during transplanting and con- tinued maintenance after transplanting. Spring planting of most tree species has the advantage of ample soil moisture and avoids the possibility that sufficient roots may not become established before freez- ing weather. If trees cannot be planted be- fore they start leafing out, it is essential for most tree species to wait until after the early rapid spring growth has slowed before moving trees in leaf.

Watering of recently transplanted trees was found to be the most important main-

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tenance practice, and under normal urban soil conditions, overwatering frequently caused more root damage than if the trees had not been watered at all. Watering should be done at the time of planting to assure adequate soil moisture in the soil ball and the soil filled around the soil ball. Following the first watering, additional water should be provided only when there has not been sufficient rain to keep the soil moist. The critical months for watering are May through September and for 2-3 years after transplating to assure that the root systems are well established. For slow-growing trees, a period of prolonged drought even during the second or third year can cause severe water stress and make them very susceptible to attack by bark borers and development of trunk cankers caused by various fungi. A newly planted tree is most easily watered if a mound of soil 4 inches high is prepared around the edge of the original planting hole. The mound of soil serves as a reservoir that should be filled with 6-8 gallons of water at 7- to 1[illegible] day intervals during the dry periods of th[e] growing season. Urban soils are frequent[ly] high in clay subsoil and tend to dra[in] poorly. Under these conditions, allowin[g] the water hose to run for prolonged perio[ds] of time in the reservoir can result in ove[r]watering and cause the roots to drown fro[m] lack of adequate soil aeration.

Extensive field surveys of recently tran[s]planted trees have shown that the hom[e]owners are largely responsible for the deat[h] and general poor vigor of their trees. Po[or] tree selection, poor planting stock, and im[]proper planting were frequent causes f[or] early decline and death of trees. Imprope[r] watering, lawnmower damage, and inju[ry] from weed killers used on the lawn we[re] found to be common causes of decline aft[er] the trees were transplanted. Researchers i[n] the Section of Botany and Plant Patholog[y] of the Illinois Natural History Survey ar[e] willing to offer advice on various tre[e] problems if you wish to write or call.

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ATURAL HISTORY
REPORTS

atural History Survey To Observe Anniversary

On June 30, 1858, the Natural History Society of Illinois was organized at Blooming-n in the office of the Illinois State Normal University. The same organization has be-me, after several transformations through the years, the Illinois Natural History Survey, cated in the Natural Resources Building in Champaign.

This year marks the 125th anniversary of this organization. Because of circumstances eventing the attendance of many friends of the Survey in June, the celebration dates we been moved to the end of September. Plans are being made for a symposium to be ld on Saturday, September 24. There will be a luncheon at the Illini Union and a more formal meal in the evening.

On Sunday, September 25, there will be an Open House and the Survey and its annex cilities, and many of the scientific research projects, will be shown and explained to sitors.

On Friday, September 23, preceding the Saturday symposium, a chartered bus tour will ke members of the staff and the public to visit three field stations; Kinmundy, where e aquaculture project is in progress; Bogota, the home of the prairie chicken research; nd Sullivan, where aquatic biologists conduct their work on Lake Shelbyville. Partici-ants will take a sack lunch and pay their own bus fares, the amount of which has not t been determined.

Inquiries about the anniversary celebration may be directed to Shirley McClellan, eneral chairman and coordinator of anniversary events, at 217-333-6882.

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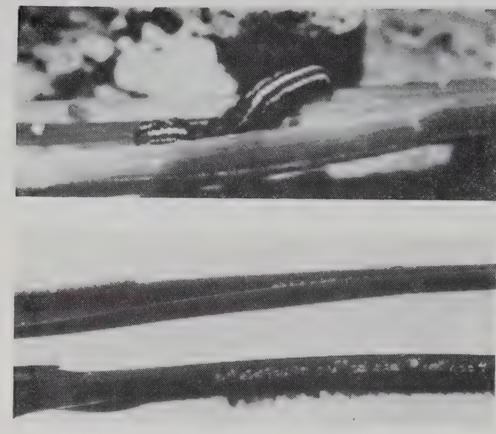
orn Damaged by Stalk Borers

The stalk borer, *Papaipema nebris,* has ot been a serious pest of seedling corn in e midwestern United States since the 930's, but recent increases in conservation llage have led to a greater incidence of talk borer problems. Female moths lay ggs primarily on grasses in fence rows, ontour strips, grass waterways, or in weedy elds during the late summer and early fall. he eggs do not hatch until the following pring. At that time, larvae first begin feed-ng on grasses but move to larger plants as hey outgrow their original hosts.

In conventionally tilled fields, damage by he stalk borer is generally confined to the irst four to eight rows of corn that are adjacent to field margins, contour strips, and grass waterways. In Illinois, larvae have been found moving into fields of corn and attacking seedlings any time from crop emergence through the end of July. In corn fields where minimum tillage, particularly no-till, is practiced, serious infestations can occur throughout entire fields. When infested fields are planted using a no-till system, herbicides used to kill the existing weeds force the young larvae to move to the only remaining food source — the corn seedlings. Corn plants attacked by the stalk borer may become misshapen or stunted, severely damaged plants usually die. Even if plants survive, they generally produce less grain than uninjured plants.



Stalk borer larva (top) feeding in giant foxtail stem. When the larva outgrows its original host plant or its host plant is killed with a herbicide, the insect may move to corn. Stalk borer eggs on quackgrass (bottom) (Photo by Eli Levine).

Eli Levine, a Survey entomologist, conducted laboratory studies to determine temperature thresholds and thermal requirements (degree-days) for stalk borer development. He found that 50 percent of the eggs hatched when 329 heat units accumulated above a threshold temperature of 47°F and that total development from egg to adult moth was completed by 50 percent of the individuals when 3,504 heat units accumulated above an overall developmental threshold temperature of 41°F. Levine also showed that female moths began laying eggs three days after emergence from pupae. These laboratory data were validated with data on egg hatch in an outdoor screenhouse and on moth catches in a light trap. The results showed that the dates of one-half the egg hatch under screenhouse conditions and one-half the moth capture by light trap were within one and seven days, respectively, of predicted dates based on laboratory data.

Knowing when common stalk borers hatch and when adults lay eggs will be a help in the control of this pest. Destroying weeds in noncrop areas prior to egg hatch can not be recommended because the cover is needed for beneficial insects and it helps combat soil erosion. However, growers may wish to mow these noncrop areas just prior to stalk borer egg laying and thus make the areas less attractive to moths. These areas, however, should not be mowed between planting and early J since this practice just drives the lar into the corn and makes problems ev worse.

In no-till fields, herbicides used to existing vegetation in spring force young larvae over to the emerging corn. reduce the potential of this occurring i subsequent season, good weed control wi in a field is essential prior to the egg-layi period of the moths (usually from m August through mid-October in northe Illinois). Levine is currently working other cultural and chemical control str egies to combat this pest.

Some Effects of Air Pollutants

Gardening, like most things, is larg what you make of it — a hobby, a serio pursuit, a game, an art, a science, or tedious chore. It can be an infinite pleasu or a vital concern. Whether your interest for ornamental shrubs, cut flowers, vegetables, successful gardening requir some knowledge of plant care basics — s texture, moisture and drainage, pH, nut tion, sunlight, weed and pest control, te perature requirement — and availability species and varieties to the home garden However, many gardeners overlook pollution which interacts strongly wi gardening.

Since most people live in or near urb areas, much gardening is concentrat where pollution levels tend to be high as result of transportation systems, space hea ing, industrial activity, and other huma oriented activities. Gardening also creat its own pollution problems from the ne for frequent and sometimes heavy use pesticides and fertilizers.

The role of gardening in providing a tractive, safe, and nutritious fruit an vegetable foods or an aesthetically pleasi landscape is beset with pollution problem Air pollutants, such as ozone, sulfur dioxid fluoride, nitrogen oxides, and other form of pollution may visibly injure plants, r duce growth rates and yield, and impa homeowner or consumer acceptance.

According to Natural History Surve Botanist Anton G. Endress, when any a pollutant impinges on plants, many facto

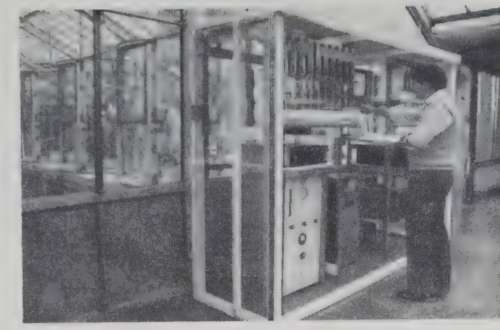
ne into play to determine what effect
: pollutant will have on the vegetation.
wide range of effects is possible, depend-
; on the interaction of the biological
aracteristics of the plant species, the
ture of the pollutant, and the environ-
ntal conditions.

The tolerance or sensitivity of vegetation
pollutants depends on (1) genetic make-
, (2) age, health, vigor, and state of
etabolic conditions, and (3) rate of pol-
tant uptake and accumulation. The vary-
g sensitivities of individual plants to
llutant injury may be due to differences
genetic constitution which controls the
ochemical and physiological tolerance for
e pollutant. Leaves at different stages of
velopment also may show different de-
ees of sensitivity to the same pollutant.

The nature of a pollutant is defined by
chemical characteristics and its persis-
nce. The response of vegetation to air
llution depends on the pollutant concen-
ation and length of exposure time. High
ncentrations of pollutants often produce
immediate and acute impact with some
sily recognized symptoms. Low concen-
ations, however, produce more subtle or
ironic effects that develop gradually and
e not readily identifiable. If plants are
posed to a pollutant mixture, the total
fect may be synergistic, additive, or
ntagonistic.

Plant response to air pollutants is par-
ally controlled by a number of environ-
ental factors such as temperature, light,
lative humidity, soil moisture, nutrient
atus, and time of year. Generally, the
nvironmental conditions that are most
vorable to plant growth also produce the
aximum air pollution response. Other
ctors such as wind direction and speed,
nd temperature inversions, are also impor-
nt because they determine the dispersal
nd dilution of the pollutants.

Vegetation weakened by stresses such as
dverse climatic conditions, a nutrient de-
ciency, or disease and insect disorders re-
ponds to air pollution much more readily
nd severely than healthy vegetation. Plants
nder stress before even mild air pollution
pisodes may not possess an adequate
efense mechanism to protect themselves
gainst pollutant injury. Similarly, plants



Botanist Anton Endress checks data from a nine-chamber pollution exposure system with various monitors, greenhouses, and controlled growth chambers (Photo by Les Woodrum, Survey Photographer).

suffering air pollutant stress may be predisposed to attack by insect or fungal pests.

The significant characteristics of the symptoms caused by ozone and sulfur dioxide are outlined below.

Ozone

Leaf markings are divided into three categories by plant type: (1) broadleaf plants — pigmented (red-brown) spots or bleached tan to white areas on upper surfaces of leaves; small irregular areas of dead tissue on both leaf surfaces that may coalesce to form large blotches; chlorosis and premature aging may occur, (2) grasses — scattered necrotic areas on both leaf surfaces; sometimes larger lesions or necrotic streaking may occur, and (3) conifers — brown-tan necrotic needle tips without separation between dead and healthy tissue.

A. Sensitive garden species or cultivars

Beans (especially white flower varieties, such as Pinto, Tempo, Sanilac, Bush Blue Lake 274), corn (especially Golden Midget, Golden Jubilee), cucumber, eggplant (wide range of sensitivity between cultivars), lettuce (especially Dark Green Boston, Grand Rapids Forcing, Buttercrunch), muskmelon, onion, potato (especially Chippewa, Cobbler, Plymouth), radish (especially Cherry Belle, Crimson Giant, Comet, Champion), spinach, tomato, grape (wide range of sensitivity), alder, crabapple, bridalwreath, honey locust, lilac, eastern white pine, privet, snowberry,

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sycamore, begonia (especially white flower varieties, such as White Comet, Cinderella White), carnation, chrysanthemum (especially Tranquility, Mt. White, Mango, King's Ransom, Touchdown, Corsage Cushion, Gay Blade), petunia (especially white flower varieties, such as Snowstorm and White Cascade).

B. Similar Markings

Red spider mite and certain insects may cause an upper leaf surface fleck of bleached tan to white areas. Some leafspot fungi may give similar patterns. Pathogen-induced tip burn in conifers may resemble ozone injury.

Sulfur Dioxide

Leaf markings are divided into three categories by plant type: (1) broadleaf — irregular bifacial (both sides), marginal, and interveinal necrotic areas bleached white to tan to brown; chlorosis may be associated with necrotic areas or a general chlorosis of older leaves may develop; diffuse to stippled colors ranging from white to reddish-brown have been observed, (2) grasses — irregular, bifacial, necrotic streaking between larger veins that is bleached tan to white; chlorosis n usually pronounced, and (3) conifers - brown necrotic tips of needles often with banded appearance; generally chlorosis adjacent tissue; needles of the same a are uniformly affected.

A. Sensitive garden species or cultivars

Bean (table), beet, broccoli, Brusse sprout, carrot (very few cultivars hav been tested), endive, lettuce, okra, pe pepper, pumpkin, radish, rhubar spinach (wide range of sensitivi among cultivars), squash, Swiss char turnip, apple (especially Golden Del cious), currant, birch, larch, mulberr pear, eastern white pine, Lombard poplar, aster, bachelor's button, begoni (especially White Comet), cosmos, fou o'clock, morning glory, sweet pea, tuli (especially American Flag, Gran Hotel, Gold Medal, Red Shine, Quee of Night), verbena, violet, zinnia.

B. Similar markings

Leafhopper injury, rose chafer injury various mosaic viruses, cherry leafspo and other fungal disease producin blotchy markings; winter, drought, an red spider mite injury in conifers.

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ATURAL HISTORY SURVEY REPORTS

SEPTEMBER 1983 NO. 229

e Natural History Survey Celebrates 125 Years of Biological Research

One hundred twenty-five years of bio-ical research have been completed by e Illinois Natural History Survey, which ll celebrate this anniversary September through September 25.

A 125th Anniversary Symposium will held on Saturday, September 24, in the edical Sciences Building on the Univer-y of Illinois campus and will be open to e public. Featured speaker at the lun-eon in the Illini Union will be Dr. Lorin Nevling, Director of the Field Museum Natural History, Chicago. Several riends of the Illinois Natural History irvey" will be honored at this time. A nited number of luncheon tickets are ailable at $8.00 each.

On Sunday, September 25, an open use will be held from 1 p.m. to 5 p.m. both the Natural Resources Building id the Natural Resources Studies Annex cated on the south campus of the Uni-rsity of Illinois. The insect, plant, fish, id other collections will be open to visi-rs in the Natural Resources Building. oecial projects in progress will be on dis-lay and will be explained by researchers the Annex.

To open the three-day anniversary cele-ration, on Friday there will be a bus tour three field stations, Bogota, where prairie hicken research is being conducted; Kin-iundy, where aquaculture projects are in rogress; and Lake Shelbyville at Sullivan, here aquaculture biologists are conduct-ig various studies. The bus will leave at a.m. from the Natural Resources Build-ig in Champaign and will return there bout 5:30 p.m. Lunch will be provided at Kinmundy (hot dogs, potato chips, and beverage) or participants may bring their own "brown bags." The bus fare will be $12.00 payable to the Survey when a reservation is made.

Two researchers of "the olden days," Charles A. Kofoid (front) and Miles Newberry, traveled the Illinois River bottoms at high water in the early 1900's.

Inquiries about the 125th Anniversary Celebration should be directed to Shirley McClellan, Anniversary Events Coordinator, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820, or call (217) 333-6882.

Bulletin to Publish Symposium Papers

Distinguished scientists of the Natural History Survey and from universities and other research organizations will present papers at the symposium, and these papers will be published in a special 125th Anniversary Symposium Proceedings issue of the *Illinois Natural History Survey Bulletin.*

Among the speakers at the symposium will be Dr. D. H. Janzen, Department of

Biology, University of Pennsylvania, whose topic will be "The Other Reasons Why a Plant Is a Good/Bad Host: The Plant as a Habitat." Dr. C. R. Goldman, Division of Environmental Studies, University of California, Davis, will speak on "Lake Tahoe, a Microcosm for the Study of Change as the Basin Is Developed."

Speakers from the Illinois Natural History Survey in the morning session include Dr. R. L. Metcalf, speaking on "Plant Karimones and Insect Pest Control"; Dr. A. S. Felsot, who will have as his topic "The Evolution of Environmental Awareness Through Pesticide Chemistry and Toxicology Research"; and Drs. R. D. Neely, D. F. Schoeneweiss, and E. B. Himelick on "Biotic and Abiotic Stresses as Primary or Predisposing Factors Affecting Illinois Trees."

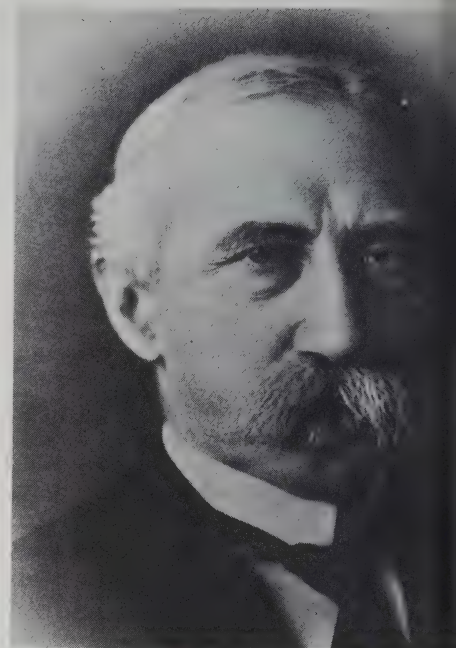
In the afternoon session, Survey speakers will be Dr. D. P. Philipp, whose topic will be "Application of Genetic Techniques to Fisheries Management"; Dr. L. M. Page, speaking on "The Evolution of Reproductive Behaviors in Percid Fishes"; and Mr. W. E. Cochran presenting "Wind Drift and Migration of Passerines."

The *Illinois Natural History Survey Bulletin* containing the Proceedings of the 125th Anniversary Symposium will be published in the spring of 1984.

Early History of the Survey

The beginnings of the Illinois Natural History Survey go back to December 1857, when Cyrus Thomas of Carbondale proposed to the State Teachers' Association that a Natural History Society of Illinois be established. On June 30, 1858, the Society was organized at the Illinois State Normal University. The constitution provided that specimens should be collected and deposited in the museum of the State Normal University.

The state charter awarded to the Natural History Society in 1861 authorized the Society to establish its own museum at the State Normal University. In 1871, as a condition for receiving financial assistance, the Society relinquished ownership of the museum to the state. The Illinois legislature in 1867 established the State Entomologist's Office, and 10 years later authorized



Dr. Stephen A. Forbes

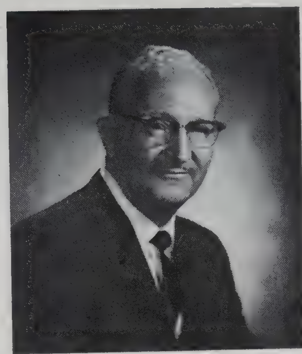
changing the Illinois Museum of Natur History at Normal to the State Laborato of Natural History.

Stephen Alfred Forbes, who later b came the first Chief of the Survey, w both Director of the State Laboratory Natural History and State Entomologist 1885 when he moved from Normal Urbana to accept an appointment as pr fessor of zoology and entomology at wh was then the Illinois Industrial Universit

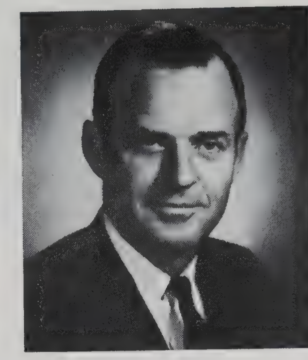
Later in the same year the legislatu approved the transfer of the Laborato from Illinois State Normal University the University of Illinois. Thus, both th State Laboratory of Natural History an the State Entomologist's Office becan located in Urbana. There they continue as separate units until 1917, when th General Assembly combined them as th Illinois Natural History Survey to carry o the intensive program of biological r search begun 60 years earlier.

There are those who speculate about th name, Illinois Natural History Surve Chief Forbes believed that "survey" mean more than mere plant and animal censuse He felt that any study should show th relationships between living organisms an their environments . . . an ecological su

Dr. Frison



Dr. Mills



Dr. Sprugel

·. This theory prevailed in all his work
‡ firmly underlined the research done at
Illinois Natural History Survey.

·phen A. Forbes Led the Way

Dr. Harlow Mills wrote of Forbes in the)th Anniversary Bulletin:

"No one has molded the character of the inois Natural History Survey so much as ·. Stephen A. Forbes, a man of irrepres- ·le intellect and insatiable curiosity, and e fourth and last Illinois State Entomol- ist . . .

"After the resignation of Cyrus Thomas State Entomologist in 1882, Governor ıelby M. Cullom appointed Forbes to at position. In 1884 Indiana University varded Forbes the Ph.D. degree by 'thesis ıd examination.' He did not have a ıchelor's degree. In 1885 he moved to the niversity of Illinois, where he was Pro- ssor of Zoology and Entomology, Director ' the State Laboratory of Natural History, ıd State Entomologist . . .

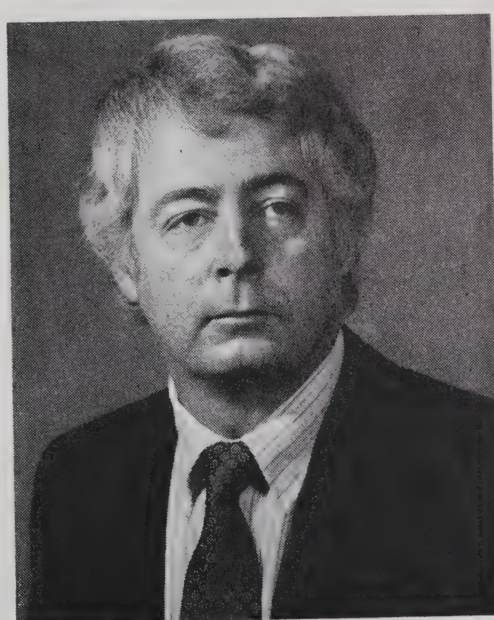
"He was especially interested in the in- ·ractions of organisms and has been called he father of ecology.' His interest covered ıl of biology. He investigated or directed ıvestigations of the food of fishes and irds, the fishes of the state, and the biol- gy of the Illinois River, and he directed ›rest surveys of Illinois . . .

"He was a member of many learned ›cieties and the recipient of many honors. ›eyond this, he was active in his church, ·elped organize the first golf club at the Jniversity, was a member of a hiking club, ·nd late in life delighted in driving an automobile. On his eightieth birthday he was arrested for speeding, an incident which gave him some pleasure . . .

"When the State Laboratory of Natural History and the State Entomologist's Office were united in 1917 to form the Illinois Natural History Survey, Forbes became the first Chief of the new organization. He held this position until his death, March 13, 1930, when almost 86 years of age."

Survey Chiefs Through the Years

The Natural History Survey has been very fortunate in having a series of outstanding men who served as Chiefs. Each in his own way has contributed to the



Dr. Paul G. Risser

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growth of the Survey, economically, scientifically, and philosophically.

Theodore H. Frison (1931-1945) grew up in Champaign-Urbana, and as a personal friend of Dr. Forbes, he knew the needs of the Survey long before he became its Chief. Along with Dr. M. M. Leighton, Chief of the Geological Survey, he concluded that the two Surveys had outgrown the space allotted to them in the Natural History Building on Green Street. The two men were able to obtain the land and funds for the Natural Resources Building, which the Surveys moved into in 1940. This was the Natural History Survey's first permanent home.

Frison, whose specialty was bees, had many interests. As soon as he became Chief, he began the development of wildlife research as a separate discipline. He was instrumental in organizing the Midwest Wildlife Conference, the initial meeting of which was held in Urbana in 1935. He was also a charter member of the Wildlife Society.

In intellect and aggressive enthusiasm, he was a worthy successor of Forbes.

A coworker cited Dr. Harlow B. Mills' (1947-1966) greatest achievement as that of "welding together the Survey into a marvelous cohesive scientific structure." The staff had more than doubled, the research budget had increased by more than 225 percent, and areas of living natural resources were being explored in depth. Dr. Mills' success in developing the Survey was partly due to his knowledge of both entomology and wildlife combined wi his remarkable ability to get people cooperate.

George Sprugel, Jr. (1966-1980) can to the Survey from the National Park Se vice in Washington, D.C., where he w Chief for the Division of Natural Scienc

His outstanding contributions to tl growth of the Survey included the buildi and instrumentation of the Natural R sources Studies Annex south of St. Mar Road in Champaign, the development an extensive grant and contract progra and the expansion of eight field statio around the state.

During a very trying time in the stat economy, Dr. Sprugel was able to keep tl staff intact and maintain the quality scientific research at a high level.

Relatively new to the Illinois Natur History Survey is Dr. Paul G. Risser, wh came here in June 1981 from Norma Oklahoma, where he was chairman of tl department of botany and microbiolo at the University of Oklahoma. A dynam and energetic man, he has implemented number of his ideas for making the Surv a smoother operating, more producti organization.

To date, he has installed a sophisticate word-processing and computer system, i creased the grants and contracts progra and is continually working to strengthe Survey relationships with other sta agencies.

On seeing him in operation, one know that he has only just begun. . . .

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ATURAL HISTORY
URVEY REPORTS

OCTOBER 1983 NO. 230

riends of the Survey" Honored

Six "Friends of the Illinois Natural His- y Survey" — Gaylord Donnelley, Leon- l Durham, Murray O. Glenn, Marion ıll, Sam A. Parr, and Robert Webb — re honored at the Survey's 125th Anni- rsary Symposium Luncheon held on ptember 24 in the Illini Union Building. amed certificates designed by Survey Il- ıtrator Lloyd Le Mere were presented to e honorees.

Gaylord Donnelley has demonstrated ; friendship and concern for conserva- ›n, research, and the arts on an interna- ›nal, national, and state scale by his ıancial support and by serving on many ıards and commissions on all three levels.

Leonard Durham, Director of the Divi- ›n of Life Sciences at Eastern Illinois niversity, has sent more than 200 student terns to work at the Survey.

Murray O. Glenn, whose certificate was cepted by members of his family, died 1981 at the age of 87. He spent 46 years ıdying the Lepidoptera (butterflies and oths) in his free time. His collections of),000 specimens presented to the Survey ıve contributed significantly to the classi- :ation and study of ecology of moths in e Midwest.

Marion Hall, Director of the Morton Ar- ›retum at Lisle, provided an insectory; : even provided housing for members of ıe Survey staff while they were working ıere. Hall has also assisted in getting ınds for Survey research.

Sam A. Parr started as a game warden, ıt as he advanced in the Department of onservation, he provided close coopera- on, support, and friendly help for wild- fe and fisheries studies at the Survey.

The sixth honoree is Robert Webb, former Director of the Dixon Springs Agricultural Station at Simpson. He hosted and in many ways encouraged research on the Experiment Station lands, ponds, and forests.

Domestic Cats in Rural Illinois

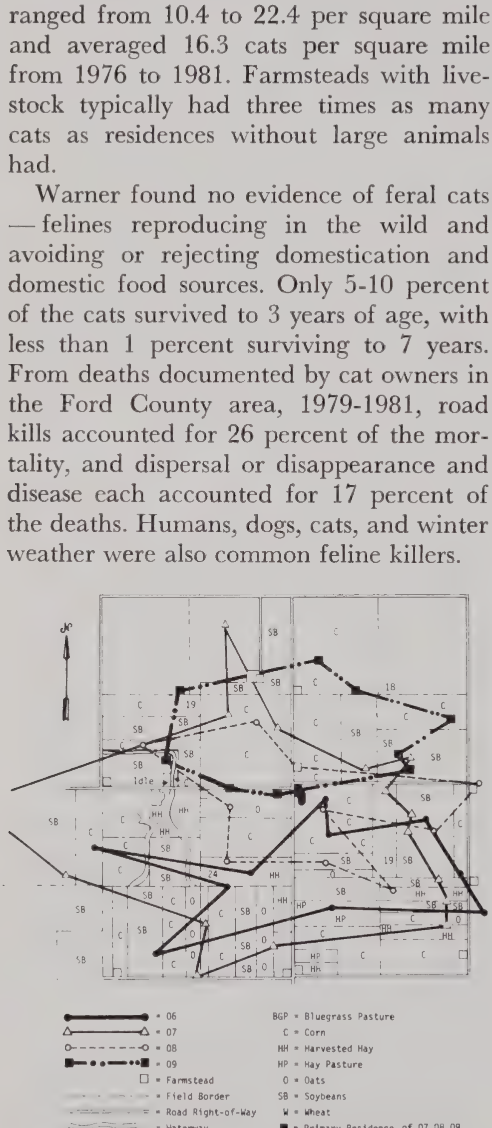
The few available facts pertaining to domestic cats in the United States suggest that these feline pets may have increased by as much as 65 percent over the past decade. The pet food industry estimates that there are about 42 million cats in this country. However, these estimates have been derived primarily from human-cat ratios for metropolitan areas. What are typical densities of these felines for rural areas? Do they significantly affect wild animal populations? In a preliminary 5-year study of a rural cat population in Illinois, wildlife ecologist Richard Warner addressed these questions.

The primary study site was a 20-square-mile area located between Sibley and Melvin in Ford County. With the cooperation of rural residents of the area, the demography of their cats was studied, 1976-1981, with emphasis directed toward the late summer population. To compare numbers of cats in this area with those living in other parts of rural Illinois, early morning roadside transect counts were conducted on this area and four other townships in central Illinois, 1977-1981. Further, the Illinois Department of Conservation provided cat census data from spring roadside counts of mammals along approximately 40 different routes throughout rural Illinois, 1981-1983. In conjunction with census work on the primary

study area, 11 cats were fitted with small, lightweight radio transmitters and were radio monitored during summer and early autumn.

Over the 5-year period, there was an average of 5.6 cats per residence in the Ford County area in late summer. Breeding females averaged 1.5 per residence with little annual variation, because residents tended to limit numbers of actively breeding females. Late summer cat densities ranged from 10.4 to 22.4 per square mile and averaged 16.3 cats per square mile from 1976 to 1981. Farmsteads with livestock typically had three times as many cats as residences without large animals had.

Warner found no evidence of feral cats — felines reproducing in the wild and avoiding or rejecting domestication and domestic food sources. Only 5-10 percent of the cats survived to 3 years of age, with less than 1 percent surviving to 7 years. From deaths documented by cat owners in the Ford County area, 1979-1981, road kills accounted for 26 percent of the mortality, and dispersal or disappearance and disease each accounted for 17 percent of the deaths. Humans, dogs, cats, and winter weather were also common feline killers.



Ranges of four domestic cats radio tracked in Ford County during July and August 1978. Male 06 tended to be vagrant during the period of study, having no permanent residence and avoiding farmsteads except for feeding. Females 08 and 09 were pregnant during the radio-tracking period.

Radio tracking of seven females ind cated a typical summer range of 278 acre with females commonly roaming within radius of about 0.9 mile from their res dences. Male cats evidenced greater mov ments, with four radio-monitored mal averaging 563 acres of range; they we commonly found within a radius of 1 miles from their residences. Ranges of m ture males tended to be separate from tho of other sexually active male cats. A grou of females and juvenile males at a give farmstead generally had overlapping rang within the territory of one mature ma (see map). Excluding farmsteads, 73 pe cent of the radio-location points for th 11 monitored cats were in some form linear habitat or edge (ecotones that we highly attractive to wildlife) such as fiel edge, waterways, or roadsides.

All cats in the Ford County area fe regularly at residences, but they al hunted, at least to some extent. In fact, a radio-monitored cats hunted, primari between 6 p.m. and 6 a.m. when temper tures were relatively cool and dew w present. During 1978 and 1979, residen noted prey brought to farmsteads by the cats; 77 percent of the residences reporte rodents; 12 percent, other small mammal 13 percent, cottontail rabbits; 9 percen pheasants; and 43 percent passerines other small birds. The evidence sugges that well-fed cats hunt regularly, compe with other predators of small animals, an destroy desirable forms of wildlife.

The data from this preliminary stud indicate that there are probably 10-15 mi lion cats in Illinois, 75 percent of whic may be free ranging in rural areas. The numbers imply that currently accepte estimates of numbers of feline pets in th country may grossly underestimate th rural population. Perhaps the sketchy u derstanding of cat numbers in the Unite States, and how free-roaming cats affe natural ecosystems, in part explains th fact that only 1 out of every 10 county-lev governments in this country attempts t control numbers of feline pets and the ownership.

Stresses Affect Illinois Trees

Before 1800, over 40 percent of Illino

as covered by forest. Today only about percent of its total acreage is forested, ss than that of any state east of the Mis-sippi River. The conversion of wooded reage to farmland, highways, and urban nd industrial development has steadily duced the forest resource base in Illinois less than 3.5 million acres, compared ith nearly 22 million acres of corn and ybeans. Even farm windbreak and edgerow trees have disappeared in many reas, resulting in increased wind and ater erosion of fertile topsoil. Because of eir relative scarcity, the protection and reservation of trees in Illinois are vital is-ues for the state.

Many of the trees remaining in Illinois re suffering from stresses caused by biotic nd abiotic factors, particularly urban rees along streets, parkways, and on pri-ate property. Biotic stresses are caused by nsects and disease organisms, while abiotic tresses result from such things as drought, looding, soil compaction, toxic herbicides nd pollutants, and mechanical injuries. n many cases, trees are damaged by the combined effects of abiotic and biotic tresses. When trees are weakened by stress, hey often become predisposed to attack by disease pathogens; consequently, out-breaks of tree diseases are common follow-ng a hard winter or after an extended drought. The severe drought of 1983 has had an obvious effect on corn and soybean yields, but it may be several years before the resulting damage to Illinois trees can be estimated.

Many abiotic and biotic stresses affect dozens of species and varieties of trees in Illinois. Although epidemic diseases, such as chestnut blight, oak wilt, and Dutch elm disease, have killed thousands of trees and are familiar to the public, many less well-known diseases cause significant dam-age each year. Keeping up to date on tree diseases requires a constantly changing and evolving program of basic and applied re-search. Plant pathologists in the Survey's Section of Botany and Plant Pathology have researched the biology and control of biotic and abiotic tree diseases for over 50 years.

Currently, three pathologists, Drs. E. B. Himelick, Dan Neely, and D. F. Schoene-weiss, each with 25 or more years of ex-perience, are conducting research projects on tree diseases. These projects include studies on the biology of specific fungal pathogens, the evaluation of fungicides for disease control, root loss and root regenera-tion during and after transplanting, wound healing, the damaging effects of lawn herbicides on trees, the cause and preven-tion of tree declines, and basic research on the histology and biochemistry of tree re-sistance to disease and the breakdown of resistance under predisposing stress.

Examples of biotic stresses affecting Illinois trees. A. Verticillium wilt on green ash. B. Nectria canker on thornless honey locust. C. Sporulating cedar-apple rust galls on red cedar. D. Anthracnose lesions on black walnut.

There is increasing demand in Illinois for trees, not only for shade and orna-mental value, but as noise and pollution filters, for reforestation of marginal lands, and for energy-yielding biomass. At the same time, trees are becoming increasingly subjected to stresses because of high costs for care and maintenance and the use of labor-saving transplanting equipment, which removes most of the root system when trees are moved. A continuing re-search effort will be required for the fore-

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seeable future to meet the issues raised by these changes.

New List of Publications Available

A long-awaited book, *Publications of the Illinois Natural History Survey, 1876-1983,* has recently been published and is now available. This list of Survey publications is far more extensive than earlier lists, and it appears in a completely different, more useable format.

This new book lists all publications of the Illinois Natural History Survey in the *Bulletin, Biological Notes,* and *Circular* series as well as in other Survey series no longer published. It also lists contributions of Survey staff members to serials and volumes published by other organizations and reprints of articles written by Survey staff and published in various journals after 1977.

The book is divided into five main sections, corresponding to the five scientific research sections of the Natural History Survey: Aquatic Biology, Botany and Plant Pathology, Economic Entomology, Faunistic Surveys and Insect Identification, and Wildlife Research. Within each section, publications are listed by author name in alphabetical order, and a standar bibliographic style is used in each listing.

Accompanying each listing is a symb indicating whether the publication is avai able through the Natural History Surve available only through the author, or ou of print or not available from the Surve Out-of-print Survey publications may b examined in the Illinois Natural Histor Survey Library.

Complete instructions for ordering publ cations are included. Single copies of Ill nois Natural History Survey publicatior are furnished free to persons requestin them. Orders for more than one copy fror educational institutions and similar or ganizations in Illinois and from others ar filled whenever possible. However, becaus of publishing costs and limited supplies, th Survey attempts to limit distribution of it publications to persons and institutions tha will make the best use of them.

To order a copy of *Publications of th Illinois Natural History Survey, 1876-198* send your request, including your nam and complete address, to the Chief, Illinoi Natural History Survey, 172 Natural Re sources Building, 607 East Peabody Drive Champaign, Illinois 61820.

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NOVEMBER 1983, NO. [illegible]

The osprey, an American hawk and an Illinois endangered species, carries fish as it flies over Rice Lake. The photograph was taken September 21, 1983 by Survey researcher Christopher Burnett.

UMP Issues First Land Report

With the publication of *Illinois Land eport: Rice Lake Conservation Area,* the linois Lands Unsuitable for Mining Proram (LUMP) has become a reality. As a sult of recent state and federal legislaon, this program establishes a process hereby Illinois citizens may petition the ate to designate certain areas of land nsuitable for coal mining. Petitioned areas ay be declared "unsuitable" if reclamaon is not feasible, or if mining would conict with existing land use plans, damage ragile or historic lands, reduce producivity of renewable resources, or increase atural hazards. The Illinois Department f Mines and Minerals (DMM) has the esponsibility to determine whether the etitioners' allegations are justified and ufficient to prohibit or limit mining of he area in question.

The Illinois Department of Energy and Natural Resources (DENR) has two roles n this process: first, to maintain a natural resource information system and data base which will be available to the public to assist petitioners; and second, to prepare a land report on each petition area to provide DMM with the information needed to make its determination. These tasks will be greatly facilitated by a computerized "geographic information system" that is currently being installed at the Illinois Natural History Survey (INHS) to manage the vast amounts of data available on Illinois' natural and cultural resources. In addition to INHS, four other DENR divisions — the Geological and Water Surveys, the State Museum, and the Division of Energy and Environmental Affairs — contribute to the preparation of the Land Reports. The INHS is specifically responsible for evaluating biological and soil resources. Land Reports must address whether mining would have any of the undesirable effects, as well as contain a detailed statement on the potential resources of the area, the demand for coal, and the impact of designating an area unsuitable on the environment, the economy, and the supply of coal.

Land Reports must state available infor-

mation objectively, but will not recommend whether the petition should be granted or denied. Following publication of the report, public comments are accepted and a public hearing is held to provide citizens with opportunities to present evidence or testimony regarding the petition.

The Rice Lake Conservation Area, subject of the first Land Report, is located in Fulton County in west-central Illinois. The area covered in the Land Report encompasses 2,694 acres managed by the Illinois Department of Conservation primarily as migratory waterfowl habitat. The petition to prohibit mining was filed in December 1982 by the Save Rice Lake Area Association, Inc., a not-for-profit citizens' group. In terms of biological resources, the Rice Lake Land Report predicts that mining and subsequent reclamation would most likely have positive impacts on waterfowl and sport fishing but negative impacts on undisturbed plant communities, endangered species, nonconsumptive recreation, commercial fishing, and various ecosystem functions. For soil resources, compaction would likely be the major problem in restoring productivity should mining occur. Reclamation of wildlife habitat would be possible but would take several decades. These predictions regarding biological and soil resources will be weighed along with numerous other factors in the decision-making process. DMM is required to rule on the petition by 28 December 1983.

Amphibian and Reptile Bulletin Updated

In 1961, the Illinois Natural History Survey published a Bulletin entitled *The Amphibians and Reptiles of Illinois*. This extremely popular state report, written by Survey zoologist Philip W. Smith, has been reprinted without revision several times and has frequently served as a model for authors of books on the amphibian and reptile faunas of other states.

The appearance of the volume precipitated publication of more than 300 articles and books citing Illinois specimens or Illinois populations of amphibians and reptiles in the ensuing 20 years. Because of the immense amount of literature, biologists involved in preparing environmental

Dr. Philip W. Smith, author of *The Amphibians a[nd] Reptiles of Illinois*, and also one of the authors [of] the new publication, *An Annotated Bibliography [of] the Illinois Herpetological Literature, 1960-1980, a[nd] An Updated Checklist of Species of the State.*

impact reports have needed a summary [of] publications that have appeared in pri[nt] since 1961.

Prompted by the environmentalists' nee[d] for recent data, Michael A. Morris (South[ern] Illinois University–Carbondale), Ric[h]ard S. Funk (Ohio State University), an[d] Philip W. Smith (Illinois Natural Histo[ry] Survey, retired) produced a new Bullet[in] entitled *An Annotated Bibliography of th[e] Illinois Herpetological Literature, 196[0]-1980, and An Updated Checklist of Speci[es] of the State.*

Publications listed in the Annotate[d] Bibliography are arranged alphabetical[ly] and numbered consecutively. Species liste[d] in the Updated Checklist of Species a[re] arranged phylogenetically and also num[bered] consecutively. The List of Titles an[d] the Checklist are cross-referenced. Thus, [a] researcher can quickly ascertain whic[h] species are discussed in each of the publ[i]cations listed and, after consulting th[e] Checklist, he can determine which publ[i]cations are pertinent for each of the Ill[i]nois species of amphibians and reptile[s]. The new Bulletin is thus a great time-save[r] for environmental biologists and provide[s] them with a means for determining th[e]

our poisonous snakes of the state found chiefly in southern Illinois. They are (upper left) massasauga or wamp rattlesnake taken in Piatt County (Photo by former Survey photographer, W. E. Clark); (upper right) imber rattlesnake; and (lower left) cotton mouth or water moccasin, both taken in Jackson County, near Aurphysboro (Photos by former Survey photographer, R. Hesselschwerdt); and (lower right) copperhead, taken n Randolph County, near Chester (Photo by former Survey photographer, Ray Hamm).

present environmental status for all Illinois pecies.

Single copies of the new publication are available upon request to: Chief, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, Illinois 61820.

No Pesticides Found in Well Water Samples

Since almost half the population of the United States uses ground water from wells or springs as a source of drinking water, great concern has been expressed recently about the potential contamination of ground water by agricultural and industrial chemicals. Ground water is also important in irrigated crop production, and more importantly, it is an integral part of the hydrologic cycle of earth. When ground water sources, or aquifers, become contaminated by pathogenic microorganisms or toxic chemicals, there are only three courses of remedial action: forbid use of the aquifer and obtain alternate water supplies; attempt to rehabilitate it; or continue to use the water but treat it to remove the contaminants.

Contamination of ground water by agricultural chemicals has been noted in 13 states. When Wisconsin reported contamination of wells in the Central Sands region by pesticides that are registered for use in Illinois, Illinois Natural History Survey scientists decided to survey ground water quality for potential pesticide residues. Insecticide toxicologist Allan Felsot, in the Section of Economic Entomology, organized an interagency committee consisting of representatives from the State Water Survey, the Illinois Environmental Protection Agency, the Illinois Cooperative Extension Service, and the Illinois Departments of Public Health and Agriculture to study the problem.

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Owing to limited funds for nonroutine monitoring of pesticide contamination, the first action was to identify areas in Illinois where there was a high risk of ground water contamination. Since it is known that contamination is highly correlated with the downward leaching of chemicals in sandy soils, four such regions in Illinois were designated high risk. Areas of this nature that were sampled included Kankakee County, Mason County, Whiteside County, and Gallatin County. Stephenson County was included as a fifth region because of the occurrence of bedrock outcroppings that are also considered susceptible to ground water contamination.

Illinois Department of Agriculture workers collected five well water samples in each region during the month of June. Both deep and shallow wells were included in the sampling protocol. The samples were divided and sent to analytical laboratories at the Department of Public Health and INHS. Waters were analyzed for a wide variety of insecticides, herbicides, and fungicides with a detection limit of one part per billion (ppb = 1 microgram of pesticide per liter of water). No pesticides were detected at the five locations sampled in Illinois. Although the United States EPA has not set any no-observed-effect lev for pesticide residues in ground water, t detection limits in this study were equal or less than the levels set for public wa supplies.

Several chemical and field factors a known to facilitate the movement of pes cides into ground water supplies. Chemi factors include the pesticide characterist of high water solubility and relatively lit adsorption to soil surfaces. Field factors clude well-drained or sandy soils with l organic matter content, high rainfall, a shallow, unconfined aquifers. Althou these factors were applicable to several the pesticides and wells tested, all wat were free of contamination.

Since remedial action for cleaning co taminated wells is very expensive and m not be feasible, the best method of ensu ing clean ground water is prevention contamination. This survey for potent pesticide contamination in Illinois grou water illustrates the cooperative inter among the various state agencies in mai taining good ground water quality in ru Illinois, and it is hoped the data generat will serve as a background for future mo itoring studies.

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icago Area Deer Research Begun

A 3-year study of deer and deer-related oblems in urban areas of Cook, Du Page, ane, and Lake counties is being concted by the Illinois Natural History rvey. It was initiated 1 July 1983. The vestigation is being funded cooperatively the U. S. Fish and Wildlife Service and e Illinois Conservation Department)OC).

An extensive deer population has devel-ed in the urban area of northeastern linois on local forest preserves, parks, d other suitable habitats. Deer herds metimes reach a point where their num-rs seemingly explode — a population omb. The evidence indicates that deer umbers in the suburban Chicago area ave reached critical proportions. Deer-otor vehicle accidents have increased armingly, with numerous injuries and amage to vehicles. Deer browsing on trees nd shrubs have caused extensive damage parks and forest preserves. Numerous omplaints have been received from area esidents about deer eating valuable orna-iental plants and damaging gardens and rops. Deer have also become a problem n runways at O'Hare International Air-ort and have been removed from the air-ort on occasion.

Urban deer problems are not unique to llinois; they exist in the urban areas of Minneapolis, Milwaukee, Cleveland, De-roit, and along the east coast. Experience n these localities has shown that deer nanagement and control strategies must e tailored to local conditions and atti-udes.

In rural areas, deer numbers are held vithin reasonable bounds by the annual removal of excess deer by hunters according to seasons and regulations carefully prescribed by the DOC staff. However, hunting is prohibited in many urban situations and alternative strategies must be sought. The urban deer problem is seen as being the sum of a series of local problems involving a number of different parks and forest preserves in the Chicago area.

Deer herd gathers in the kind of natural habitat they seek, but are sometimes unable to find (Photo by W. N. Wandell).

A basis of current, factual data is essential to solving wildlife-related problems. It is the responsibility of the Conservation Department to work with various local governmental agencies and with the owners of private property in trying to solve deer-related problems. The objective of the Survey in the deer study is to collect, analyze, and make such information available both to the DOC and to local units of government.

The urban deer research study project team is being supervised locally by Dr. Jim Witham, who is headquartered on land owned by the Cook County Forest Preserve District. He is being assisted by Jim Chelsvig, who has been transferred to the area

from Champaign. Dr. Glen C. Sanderson, head of the Survey's Section of Wildlife Research, is the principal investigator for the project. For several years, scientists of the Section of Wildlife Research have been studying management strategies for deer in the rural areas of Illinois.

The primary objectives of this urban deer study are to determine how many deer are in the four-county urban area, where they are, how fast their numbers are increasing, what their behavior and habitats are, whether they are healthy, how much damage they are causing, how many need to be removed for effective control, and relative costs of several possible methods of control.

Along with what the biologists refer to as the "population study," a management study will be initiated. The management study will evaluate methods of capturing deer on metropolitan parks and forest preserves and subsequently releasing them elsewhere in the state. In the past, Department of Conservation and Survey biologists have captured and transplanted relatively small numbers of deer, primarily for research and restocking purposes. However, capture and removal may not prove to be effective at a scale demanded by deer in the four-county urban region.

Information from DOC biologists and Survey studies indicates that the problem of deer in urban areas may relate, in part, to deer immigrating considerable distances from rural townships, as deer are highly mobile. Thus, Survey researchers have been asked to census deer throughout Cook, Kane, Lake, and Du Page counties to determine deer abundance, any damage problems, and the attitudes of landholders and homeowners toward possible control methods for deer in these four counties.

There is general agreement that a real problem exists and that it warrants immediate attention. It may be necessary to remove several hundred deer from the four-county area. A new crop of fawns comes each spring, and the surplus will probably need to be removed each year if effective population control is to be maintained.

Mexican Bean Beetle Population Is Monitored in Illinois

In Illinois, the Mexican bean bee
(*Epilachna varivestis,* Coleoptera: C
cinellidae) has historically been conside
only as a pest of garden beans, and seld
if ever, has it been found attacking s
beans. However, this beetle is a well-kno
pest of soybeans in several eastern coas
plain states, and recently it has beco
established as a serious soybean pest
areas of Ohio, Kentucky, Tennessee, a
throughout most of Indiana. Yearly chan
in the composition of the arthropod fau
on Illinois soybeans have been clos
monitored by researchers in conjunct
with the Illinois Cooperative Extens
Service. Monitoring the incidence a
trends in soybean-feeding arthropods i
considered an important component of
state's Insect Pest Management (IP
program. Any crop grown over such
tensive areas as soybean in Illinois is hig
vulnerable to exploitation by "new" pe
resulting in serious economic impact.

Thus, the Mexican bean beetle h
been the focus of attention in this resp
for some years, due to the apparent expa
sion of its range westward in states neig
boring Illinois. Although as early as 19
the beetle was observed feeding on so
beans in a single field in east-central Il
nois, there has never been an infestation
economic consequence. However, in 19
Survey researchers Marcos Kogan a
Charles Helm observed moderate popu
tions of this insect in two counties bord
ing Indiana, and in 1982, the first instan
of economically damaging populations
this beetle occurred in these same count
Outbreaks were reported late in the seas
in both conventionally planted and la
planted or double-cropped beans as beet
massed in the few remaining green fiel
Although nearly every field sampled co
tained a few adult beetles in the ea
spring of 1983, there have been no repo
or observations of beetles on subseque
visits. However, perhaps most alarmi
was the report of a heavy population in
field nearly 50 miles due west of th
original outbreaks.

exican bean beetle is shown on damaged soybean
af (Photo by T. E. Benner).

Outbreaks such as this necessarily raise le question of changes in adaptation of the eetle to soybeans and/or changes in le susceptibility of Illinois soybean plants) the pest. Both hypotheses are currently eing tested in the laboratory. Presently iere appears to be little evidence that iese apparent changes in feeding prefernce of Illinois beetles are due to genetic hanges in the beetles themselves. There is ome evidence that these changes are reated to the quality of the plant; however, oth of these hypotheses require considerble additional testing.

Continuous monitoring of not only eetle populations, but also agricultural ractices and ecological conditions, in adlition to laboratory studies, will provide a nuch better understanding of the mechnisms involved in the expansion of this eetle's range and host preference.

Jrban Pesticide Usage by Arborists

Seventy-four percent of the population n the United States lives in urban areas urrounded by 200 million trees and 800 million shrubs. The use of pesticides to keep these plants free of insect pests and diseases is increasing. Advancement in pest control procedures is years behind the current developments in agricultural fields and urban Integrated Pest Management (IPM) is in its infancy. One of the major users of pesticides in urban areas is the arborist. Commercial arboriculture is a 1 billion dollar per-year industry involving pruning (37 percent), spraying (18 percent), and tree removal (16 percent). No data assessing the use of pesticides by arborists are available.

The research objectives by Dan Neely and Eugene Himelick, plant pathologists, were to determine 1) the pests to be controlled, 2) the pesticides used to control them, 3) the host plants being treated, 4) the quantity and cost of pesticides applied, 5) the time of application, and 6) the equipment being used. The relative economic importance of pesticide application to the total value of services offered by commercial arborists was also sought.

The objectives were fulfilled through questionnaires and personal interviews. Separate questionnaires were prepared for the commercial and the municipal arborists to present their differing interests, methods, and goals. Questionnaires were mailed to 529 tree experts with licenses to practice commercial arboriculture in Illinois.

Of the 529 questionnaires mailed to licensed arborists, 156 were returned. Of the 40 questionnaires mailed to arborists that are employed by municipalities, 20 were returned. These, plus the 16 licensed arborists employed by municipalities, composed the data sample for municipal arborists.

The results can be summarized as follows. Most of the arboriculture firms perform tree maintenance services other than tree pest control. In 29 percent of the firms, the pest control income is less than \$7,000 annually. In 63 percent of the firms, this income is substantial, from \$8,000 to \$150,000. The remaining 8 percent is over \$150,000. Most of the pest control services are performed for homeowners on private grounds. The training of employees who operate sprayers for arborists is primarily on the job. Applying the pesticide at the proper time seems to be the most difficult of the problems related to tree and shrub pest control.

The insecticide usage by Illinois arborists is substantially greater than the fungicide

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usage: thirteen times as many applications of insecticides alone as fungicides alone, and two times as many insecticides alone as combinations of insecticides and fungicides. The disease most important to commercial arborists is scab, followed by rust and anthracnose. The most important insect problem is scale, followed by aphids and bagworms. The 20 arborists who responded on the municipal arborist survey form confirmed the Neely and Himelick opinion that Dutch elm disease has been the major problem for Illinois cities.

The size of the municipal budgets to be used at the discretion of the muncipal arborists for pest control activities is small. Three arborists state they have no funds specifically to be used for tree-pest activities; another three of 12 responding to this question had over $20,000 in the 1982 budget. The average for the 12 cities was $15,000 for protection of city trees. Application of sprays at the proper time is rated the most difficult problem for municipal arborists; diagnosis of the problem is rated the second most difficult. The apparent need to apply substantially more insec cides than fungicides was similar in bo groups.

An effort was made to personally inte view arborists with a range in interests a size of operation. An effort was also ma to select arborists distributed geograp ically throughout Illinois. The tree ho with eight or more insect-pest problems i clude crabapple, elm, honeylocust, mapl oak, and fruit trees. The tree hosts wi three or more disease problems are cra apple, hawthorn, oak, and fruit tre June was the month of greatest activity f insecticide application with almost 1 m lion treatments to trees. April and M were the only months with extensive trea ments with fungicides. The dollar value pesticides purchased by licensed comme cial arborists in Illinois in 1982 was su stantial, averaging $8,500. Of this, 15 pe cent was for fungicides and 85 percent w for insecticides. According to the calcul tions of Himelick and Neely, over 2 millic dollars were spent by licensed arborists Illinois for pesticides in 1982.

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[M]onographic Study of *Torula*

The genus *Torula* was established by [P]ersoon in 1795 for fungi with dark, bead-[lik]e, one-celled, asexual spores (conidia). [B]ecause of this vague generic concept, a [la]rge number of unrelated organisms have [be]en grouped in this genus which presently [co]ntains nearly 600 species. Included [a]mong these fungi are pathogens of man [a]nd animals which cause localized swollen [le]sions on the hands and feet (*Torula* [m]*anselmei*) as a result of subcutaneous in[fe]ctions or which cause pulmonary nodules [o]r systemic infections of the lungs (*Torula* [n]*eoformans*). The identifications of many [m]edically important fungal pathogens are [d]ifficult because of incomplete descriptions with poor or no illustrations. This, in turn, affects diagnosis and treatment. *Torula* fungi are commonly encountered in soil, water, air, and on decaying and living substrates. They represent an important segment of any mycological flora, and studies that will define the generic and species concept in *Torula* are necessary for a better understanding of the species and their accurate identification by mycologists and persons in allied professions.

Presently, Lee Crane, Survey mycologist, is attempting to establish the range of variability in *Torula herbarum,* the species which delimits the group (genus). In this study, the classification of the genus will be based on developmental and morpho-

Photomicrograph of *Torula herbarum* illustrating the heavily melanized, coronate, conidiogenous cells and chains of conidia. X 2,000 (Photomicrograph by Lee Crane).

logical characters. In *T. herbarum* and other bonified species, the cell that produces the asexual spores (conidia) appears to be the diagnostic character. It is crown-like and heavily colored at the base. The conidia are ornamented with warts, and the spore size and number of cells per conidium are constant within a range for each species. All recognized species of *Torula* appear to fall within two basic groups: those with the conidia borne singly and those with conidia in chains. The biological constancy of these characters will be studied. A key and detailed descriptions with illustrations will be provided for the accepted *Torula* species and any new species. Information for each species on typification, synonomy, geographical distribution, and host or substrate range will be provided. The monograph will include an index of all names published in *Torula* along with the source of publication, history, and present disposition.

This study will provide basic biological information on a genus about which there has been much confusion since its establishment and will serve as a reference manual to the early mycological and medical literature where species named as *Torula* are cited.

Effect of Stalk Borer Injury on Corn Yield

Female moths of the stalk borer, *Papaipema nebris,* oviposit primarily on grasses in fence rows, contour strips, grass waterways, or in weedy fields during the late summer and early fall. After the eggs hatch the following spring, the larvae begin feeding on grasses but move to larger plants as they outgrow their original hosts. Corn may serve as this larger plant if planted in or near infested grasses. Stalk borer larvae injure corn plants in two ways: by burrowing into the base of the plant and tunneling up through the center of the stalk or by entering the plant through the whorl and tunneling down. Both types of attack may result in misshapen or stunted plants and severely damaged plants may die.

The recent increased use of conservation tillage practices by field corn producers the central corn belt has led to a great incidence of stalk borer problems. In pa ticular, serious infestations can occ throughout entire fields where no-till practiced if these fields harbor stalk bor eggs and larvae before spring plantin After herbicides are applied to kill exis ing weeds, the stalk borer larvae are forc to attack the corn seedlings, the on remaining food source. For conventio ally tilled (fall-plowed, spring-disked) co fields, stalk borer damage is usually r stricted to the first four to eight rows corn that are adjacent to field margir contour strips, or grass waterways contai ing stalk borer infested grasses.

Eli Levine, a Survey entomologist, a sessed the impact of natural populations stalk borer larvae on the ability of co plants to recover after injury was inflict at different plant growth stages (leaf stag two through eight). The study was co ducted in three no-till fields and three co ventionally tilled or reduced tilled (fa chisel-plowed) fields over the course 3 years (1980 to 1982). He found th yield losses resulting from injury by larv were due to both the reduction in th number of plants producing ears and th reduction in grain weight per ear. I general, seedlings injured earlier in deve opment produced fewer harvestable ea (plants producing ears that contained kernel weight of 30 or more grams at 15 percent moisture were considered harves able) and less grain than plants injure later in development. Injured plants al tended to sucker (grow additional shoots more than uninjured plants. He also foun that of the injured plants that did not s harvestable ears, over 58 percent survive to harvest time. These nonproducti plants probably competed with the u injured plants for sunlight, moisture, an soil nutrients until harvest. Levine did n find new damage in plants beyond th eight-leaf stage. He also found that dan age to corn in plots adjacent to field ma gins containing stalk borer-infested grass varied by row with the row immediate bordering the field margin generally su

flated caterpillar of *Dasychira* ɪgans (Barnes & McDunnough), ɪllected in 1898 and first illus- ated in a 1913 publication on ssock moths (Photo by G. L. odfrey).

Caterpillar of *Dasychira basiflava* (Packard) on white oak, Mississippi Palisades State Park, Carroll County, Illinois, June 1983 (Photo by G. L. Godfrey).

White-marked tussock moth caterpillar, *Orgyia leucostigma* (J. E. Smith), normally feeds on deciduous trees and shrubs, rarely found on soybeans (Photo by G. L. Godfrey).

ɪining the most damage. The results of ɪis study should be useful in the develop- ɪent of damage thresholds for this pest. /hen this information is generated, corn roducers will have a better idea when ɪemical control is economically justified.

'asychira vagans: 'ctogenarian Visitor

A well-traveled, 86-year-old tussock ɪoth caterpillar specimen (first picture), *'asychira vagans* (Barnes and McDun- ɔugh), that formerly resided in Illinois sited the Survey briefly in 1983. The ɪterpillar was collected in the summer of 398 near Meach Lake, Quebec, Canada, as inflated for preservation, and spent the ɛxt 30 years in the collection of the late 'r. Williams Barnes of Decatur. In the ɪrly 1930's, it, along with the rest of ɪe large Barnes Collection, was sold to the 'S Department of Agriculture which 'ansferred its custody to the United States 'ational Museum of Natural History 5mithsonian Institution), Washington, '.C. Its temporary return to Illinois was 'ranged by Associate Insect Taxonomist 'eorge L. Godfrey, who spotted it in the 'ational Museum and recognized it as the ɪecimen that had been illustrated in a 913 publication on the Lymantriidae (tussock moths). The clue was a misplaced, black seta (hair) on the right side of the body about one-third of the way from the head.

Godfrey normally does not check caterpillars to see if their hairs (setae) are in place before photographing them, but in this case was involved in a study of the North American tussock moth caterpillars and was searching for museum specimens to complement those that he had reared (middle picture) in order to complete the project.

The lymantriid study that was recently completed is Godfrey's third contribution on caterpillars to a national project about immature North American insects that F. W. Stehr, Michigan State University, is coordinating. The lymantriids include several major and minor pests of trees and shrubs. Examples from Illinois include the notorious gypsy moth caterpillar, *Lymantria dispar* (Linnaeus), and the lesser known, white-marked tussock moth caterpillar, *Orgyia leucostigma* (J. E. Smith) (third picture). Presented in the study are photographs of representative caterpillars of all the North American lymantriid genera, a synthesis of the known host plants, phenological and distributional information, and the basic diagnostic characters for identifying the caterpillars.

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Rural Cats — A Look into the Future

A recent article in the *Natural History Survey Reports* described a free-ranging rural cat population in central Illinois. What are likely trends for future numbers of cats in this state? Wildlife Ecologist Richard E. Warner estimates that currently there are approximately 5.5 million cats in Illinois; further, if national trends continue for a growing percentage of households with cats and more cats per household, there could be up to 10-15 million cats in this state by the year 2000.

Because free-ranging cats prey upon wild animals, a potential change in densities of felines in rural areas is an important consideration. There are two shifts occu- ring in the human population that sugge a high probability of greater numbers rural cats in the future. First, there ha been about 850 new hobby farms (less th 50 acres) established each year in Illin since the late 1960's. Secondly, rural co- munities are expected to sustain a grow in numbers of households. For examp 75 percent of the small towns in the southernmost counties of Illinois are pre- ently growing. Hence, as people show growing preference for rural living, the is little doubt that feline pets will appe in growing numbers on the rural lan- scape.

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NATURAL HISTORY SURVEY REPORTS

FEBRUARY 1984, NO. 234

ndangered and Threatened ecies in Illinois

In his fervor to improve his lifestyle and onquer all natural barriers, Man has exloited and changed most of the native abitats of the earth. As one result, the atural process of extinction has been rastically altered and significantly increased. Since the early 1600's, over 500 pecies of native plants and animals have ecome extinct. Many others have been rought to or near the edge of extinction nd are considered, respectively, endanered or threatened.

The official list of endangered and hreatened plants for Illinois contains 363 species. The official list of such vertebrates for Illinois includes 13 fish, 11 amphibians and reptiles, 40 birds, and eight mammals. Of these, one fish, four birds, and two mammals also are listed as federally endangered. While no official state list of endangered or threatened clams presently exists, four of the 23 federally endangered clam species are known to occur in Illinois.

anthocephalus xanthocephalus, yellow-headed blackird, in *Typha*, cattail marsh (Drawing by Ms. Patti atusic).

In Illinois, endangered species are defined as those naturally reproducing native species likely to be extirpated from this state in the near future. Threatened species are those likely to become endangered in the near future. Most of the native species of plants and animals existing in Illinois today are surviving in marginal or detached habitats. Of principal concern is the protection of critical habitat necessary for the successful reproduction of endangered and threatened species within the state.

The Illinois Department of Transportation (IDOT), Bureau of Location and Environment, is required by the Endangered Species Act of 1973, as amended, to conduct biological inventories for the purpose of identifying federally listed endangered and threatened species likely to be affected by its highway construction projects. Plant and animal species listed as endangered or threatened in Illinois by the Illinois Endangered Species Protection Board are considered in a similar fashion. The Illinois Natural History Survey (INHS) in cooperation with IDOT, has conducted such inventories since 1981. Survey staff members in the Sections of Faunistic Surveys and Insect Identification and Botany and Plant Pathology primarily have been responsible for these inventories. Scientific staff members include Project Coordi-

nator W. U. Brigham; Project Manager, M. J. Wetzel; Botanists, K. R. Robertson, R. C. Moran, and W. McKnight; and Zoologists, L. M. Page, L. Suloway, R. Grosser, M. E. Retzer, J. Kasprowicz, M. Morris, and S. L. Sandberg.

The objectives of these studies are (1) to locate all existing populations of the endangered and threatened plants and animals in the study area; (2) to establish from literature, field observation, and consultation with experts, the boundaries and abundance of each population; (3) to document the known life history and the ecology and environmental requirements of the species; and (4) to assess the potential impact of the proposed project on these populations within their specific habitats.

The collective efforts of the Natural Land Institute, Illinois Natural Areas Inventory, Illinois Department of Conservation, Illinois Endangered Species Protection Board, the Audubon Society, the US Fish and Wildlife Service, Morton Arboretum, The Nature Conservancy, and many other public and private groups have provided the information needed to assess the status of native species in our state. While the principal objective of these inventories is to protect critical habitat used by Illinois endangered and threatened species from reduction or elimination from highway construction, the information assembled also can be used to address the special problems of these species. Preservation of land, reintroduction of native species, management of natural and artificial habitat, breeding programs, and life history studies are all options available for managing endangered and threatened species once critical habitat has been identified. Their current status as "endangered" and "threatened" species is the result of the expansion of the human species. Thus, it is appropriate that we make the effort to assure their survival. Present and future land ethic in Illinois must give priority to its natural resources.

Fungal Pathogens of Insects in Alfalfa

Alfalfa is the world's most valuable cultivated forage crop. In the United States, it is surpassed in total acreage only by corn, soybeans, and wheat. This forage crop is recognized as providing the best food value for all classes of livestock as it produces about two times as much digestible protein as clover and four times as much as timothy-clover hay or corn silage. In addition, alfalfa adds nitrogen to the soil, improves water filtration, and improves soil structure.

Alfalfa is grown as a perennial and as such is a unique agroecosystem. It is relatively long lasting (3-5 years) but is harvested every 4-6 weeks which creates short-term cycles. Because of its relatively low per-acre economic value, alfalfa can tolerate a level of insect pest presence which might not be allowable in another crop. Therefore, alfalfa is ideal for the application of integrated pest management techniques.

Of the many insects which live in alfalfa, the alfalfa weevil (*Hypera postica*) and the potato leafhopper (*Empoasca fabae*) are considered the primary pests. Alfalfa weevil larvae occur in the spring causing serious economic damage by defoliating the plant. The adult alfalfa weevils disperse to wooded areas near the alfalfa field to remain dormant through the hot summer months. In the fall, the adults migrate back to the field and begin laying eggs. The potato leafhopper, on the other hand, does not overwinter in Illinois. This small green insect migrates from the gulf coast states each spring and becomes a pest during the second and third alfalfa growing periods in midsummer. It causes damage by sucking plant sap and blocking conductive tissues. This feeding causes leaf tips to yellow and die which leads to a reduction in total protein produced.

Both of these insects have fungal pathogens which attack them. The alfalfa weevil is attacked by *Erynia phytonomi*. This pathogen was initially discovered in 1974 in Ontario, Canada, and since then has spread rapidly throughout the United States. At times, disease incidence may range as high as 100 percent in certain populations of weevils given ideal microclimatic conditions. When this disease occurs early enough in the weevil's life

cle, economic damage is averted, thus ducing the need for an insecticide appli- tion. Presently, Survey entomologists are orking to determine what factors are nportant in the initiation and spread of iturally occurring epizootics and how this sease affects other biological control ents (e.g., parasites and predators) of e alfalfa weevil.

Erynia radicans is a fungal pathogen hich infects the potato leafhopper. In 982, Survey entomologists received a leaf- opper with this disease from researchers Wisconsin. This generated an interest in e potential use of this pathogen as a ological control agent. A literature sur- ey indicated that very little research has een done with this pathogen, but several ports indicated that at times potato afhopper populations had been severely ffected by *E. radicans*. A survey of Illinois 1983 failed to locate any leafhopper opulations which were affected by any athogens. However, a trip to Wisconsin ielded several leafhoppers infected with *. radicans*. Presently, researchers are orking with these isolates to determine: 1) basic transmission and epidemiological arameters involved with this pathogen- ost system; (2) host range of *E. radicans;* 3) mode of overwintering; and (4) why his pathogen was not found in Illinois in 983.

Once the basic biology of these two athogens is understood, integrated pest nanagement tactics may be developed which would facilitate their use as biological control agents.

Abandoned Mines in Northern Illinois

Illinois has an abundance of coal with approximately 65 percent of the state overlying coal-bearing strata. Ever since the first mine opened in 1810, Illinois has been an important provider of this resource. However, until 1962 little was done to protect the environment. During that year, the first surface mine reclamation law became effective in Illinois, and in 1972 the Pollution Control Board issued regulations concerning water quality from deep- and surface-mining operations. Consequently, a large number of sites, abandoned prior to the 1960's, were never reclaimed and many still pose environmental hazards.

During 1982, Claus Grunwald and Diane Szafoni of the Illinois Natural History Survey were granted a contract from the Abandoned Mined Lands Reclamation Council to study revegetation possibilities of the abandoned mines of the Longwall District in northern Illinois. Louis Iverson, also a Survey staff member, has since joined the research group. Deep mines in the Longwall District were in operation from 1875 to 1930, and the area presently contains over 100 refuse piles, generally lying within 20 miles of the Illinois River between Morris (Grundy County) and Peoria (Peoria County), Illinois.

Typical abandoned mine site in northern Illinois, near Standard, showing severe erosion and lack of vegetative cover.

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Revegetation of most of these mine sites by natural processes, even after 50 or more years, has been negligible and thus causes a number of environmental problems, including sedimentation and decreased water quality of streams. The natural establishment of vegetation has not occurred because of generally very steep topography, lack of moisture, relatively high soil acidity, and the exposure to poor soil texture and fertility conditions.

The mine waste represented material removed from directly above and below the No. 2 coal seam during the Longwall mining process. A complete inventory of plants growing on the poorly revegetated pile was conducted during the summer and fall of 1982 and the early summer of 1983. A total of 40 species of vascular plants was found, with most of the vegetation confined to the lower slopes. Even though the mine has been closed for many years, most species represent early successional stages. Measurements of water potentials and temperatures of the gob material revealed excessively harsh growing conditions, especially on southern slopes. The combination of steep slope and poor moisture retention of the gob material makes water availability an important limiting factor restricting plant growth.

Chemical analyses of the mine gob materials have revealed additional potential problems. Although the pH ranges between 3.2 and 4.0, lime requirements to correct this problem were reasonably low. Nitrogen, phosphorus, and potassium were found to be extremely deficient, and ferti izer would be required for proper pla growth. The gob material was also fair high in aluminum and iron which cou present a toxicity problem at low pH however, adjustment of pH through limir should correct any toxic effect.

To further explain some of the nutrie problems, a greenhouse experiment h been devised which eliminated water as limiting factor. The soil modifications th were tested were lime, fertilizer, lime pl fertilizer, and sewage sludge. The tot biomass accumulation plus the shoot: ro ratios were monitored for three grass (tall fescue var. 'Kentucky 31', little blu stem, and side-oats grama) and two le gumes (black locust and crownvetch). Wit all species, except black locust, the add tion of sewage sludge produced the grea est production of plant biomass. Blac locust responded best to fertilizing. In ger eral, the fertilizer treatment ranked sec ond and the lime plus fertilizer third, fo lowed by the lime treatment and the san treatment. The poor responses to sand c lime treatments underscore the nutrier deficiency problems; gob texture or pl problems are secondary in importance. I would appear from these results that th use of sewage sludge, both for its wate retention and nutritive qualities, should b pursued further for the revegetation c northern Illinois mine gob piles whe economically and environmentally accep able.

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ATURAL HISTORY

URVEY REPORTS

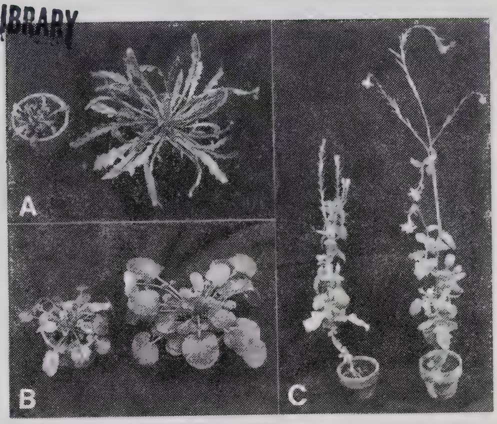
MARCH 1984, NO. [illegible]

wly Discovered Plant Hosts
piroplasma citri

3rittle root has been the most destruc- disease of Illinois horseradish since it first reported in 1936. In 1981, plant hologists and entomologists at the Uni- sity of Illinois and the Illinois Natural story Survey, in cooperation with re- rchers at the University of California at vis, provided a key to understanding ttle root with their reports that the ısal agent of this disease is the helical cteria-like organism *Spiroplasma citri*. e Illinois team further demonstrated it the beet leafhopper (*Circulifer ten- us*) can transmit *S. citri* to and from rseradish, and that the aster leafhopper *lacrosteles fascifrons*) is also an experi- ntal vector of this pathogen.

Many questions remain concerning the idemiology of brittle root in Illinois. The ease is present in horseradish at a very v level almost every year and has oc- rred at irregular intervals in epidemic oportions with heavy crop losses. Do leaf- ipper vectors bring *S. citri* into the state m the western United States, where *S. ri* causes a major disease of citrus? Or there plant hosts, especially weeds, ving as reservoirs of *S. citri* in Illinois or ewhere in the Midwest from which leaf- ppers could transmit this pathogen to rseradish?

Recently, Entomologists Karen O'Hayer, erald Schultz, and Catherine Eastman, d Plant Pathologist Jacqueline Fletcher nducted a study to explore the feasibility the local weed reservoir hypothesis. *S. ri* has a wide experimental host range ich includes several wild brassicaceous ants, and field-collected weed species



Chlorosis and stunting resulting from *S. citri* infection in (A) shepherd's purse, (B) yellow rocket, and (C) wild mustard. In A-C, the plants on the left were exposed to infected *C. tenellus* and the plants on the right to control leafhoppers.

have been found to harbor spiroplasmas in California and Arizona. No work had been done, however, to determine the susceptibility of wild plant species to midwestern isolates of *S. citri*. O'Hayer and her colleagues set out to determine if three brassicaceous weeds common in the Midwest — yellow rocket (*Barbarea vulgaris*), wild mustard (*Brassica kaber*), and shepherd's purse (*Capsella bursa-pastoris*) — could serve as sources for transmission of an Illinois isolate of *S. citri* to horseradish.

First, beet leafhoppers injected with suspensions of cultured *S. citri* were used to inoculate yellow rocket, wild mustard, and shepherd's purse test plants to determine their susceptibility to *S. citri* infections. Injected leafhoppers and non-injected controls were held on sugar beet plants for 22 days to allow time for spiroplasma multiplication within the injected insects and infection of their salivary glands. Then they were caged in groups of 10 on five

seed-grown test plants of each weed species. After 7 days, surviving insects were transferred to fresh test plants of the same species for another 7 days. Chlorosis and stunting of young leaves characteristic of *S. citri* infection developed in 4 of 10 yellow rocket and shepherd's purse test plants and in six of nine wild mustard. Enzyme-linked immunosorbent assay (ELISA), a diagnostic test which uses serum containing antibodies generated in response to a specific pathogen, confirmed the *S. citri* infections. All test plants caged with control leafhoppers remained free of symptoms and were negative by ELISA.

To determine if beet leafhoppers could acquire and subsequently transmit *S. citri* from these infected weeds, leafhopper nymphs were confined in separate cages with four source plants or four healthy plants of each weed species for 7 days and were held on sugar beet plants for another 26 days. Insects fed on source plant species were then caged in groups of 10 on five test plants of the same species and on five horseradish test plants. After 7 days, surviving insects were transferred to fresh plants of the same species for another 7 days. Leafhoppers previously confined with either infected yellow rocket or shepherd's purse plants transmitted *S. citri* to all 10 yellow rocket or shepherd's purse test plants, respectively, and to all 10 horseradish test plants. Leafhoppers confined with infected wild mustard transmitted the spiroplasma to all 10 wild mustard and to 9 of 10 horseradish test plants. Plants were diagnosed as infected by symptomatology and confirmed by ELISA. All test plants caged with leafhoppers fed previously on healthy weeds remained free of symptoms and were negative by ELISA.

Preliminary searches for spiroplasma-infected weeds near horseradish fields in Illinois have been unsuccessful, but intensive studies have yet to be conducted. The report that yellow rocket, wild mustard, and shepherd's purse can be infected by *S. citri* expands the host range of this spiroplasma and is the first study to use a midwestern isolate. The demonstration that these weed species can serve as sources for transmission of *S. citri* to horseradish is an encouraging first step in long-term resear to determine the possible involvement local or regional wild plant populations the epidemiology of brittle root disease.

Prairie Chicken Management — Cycles, Densities, and Thresholds

Illinois' long-term data base on prai chickens is matched by few other sta within the range of the species. Yet, ad quate answers to some basic questions a still needed. For example, is there a mi mum population size below which dem graphic factors, environmental variatio natural catastrophes, or genetic fact such as inbreeding, may depress a popu tion to extinction? Grouse such as prai chickens sometimes show cyclic fluctuatio in their numbers at intervals of about years. Are prairie chickens in Illin cyclic? If so, how much variation in pop lation densities can be expected betwe cyclic lows and highs? Grassland habi suitable for successful nesting has lo been recognized as the critical factor lim ing the abundance of prairie chickens Illinois.

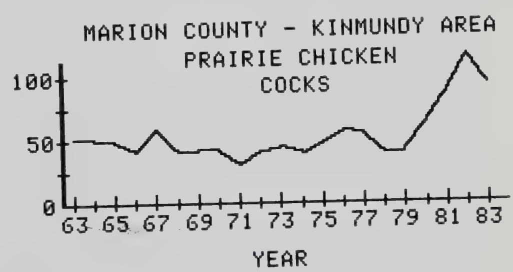
But how much grassy nest cover is quired for the long-term preservation the species? Should nest cover be a sing large block? Or, if a scatter pattern of san tuaries is best, there are questions of nu ber, size, shape, and dispersion to answ These topics were addressed by Illin Natural History Survey Wildlife Ecolog Ron Westemeier at a recent meeting the National Prairie Grouse Techni Council in Emporia, Kansas.

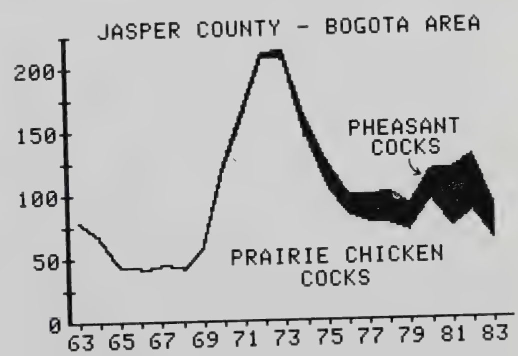
Some geneticists believe that, in gener a population must not fall below 50 in viduals, yet others indicate that for th species like the prairie chicken that p form their courtship and mating activit on special display grounds or areas, t minimum population size may be more li 150-200 individuals. The prairie chick flock near Bogota in Jasper County a proached the supposed threshold of birds in the mid-1960's, but recover dramatically to some 400 birds in 197 1973. Currently, the Bogota flock is do to 100-120 birds, probably due principa

Prairie chickens on booming ground of their natural habitat. Cocks are larger and more ornate birds than the hens.

› competition by pheasants. The prairie hicken flock near Kinmundy in Marion County was down to about 50 birds in 971, but by 1982 this flock probably exeeded 200 individuals. These responses provide some basis for speculating that a ninimum population size for prairie hickens may be somewhat below 50 birds.

A basic phenomenon to be considered in tudies of the dynamics of grouse populaions is the tendency for their numbers to cycle at intervals of about 10 years. The prairie chicken population in Jasper County showed (1) probable highs in 1962-1963, (2) definite highs in 1972-1973, and (3) if pheasant counts are added, a high was also evident for 1982. Pheasants were added to the prairie chicken counts because of their overlap in ecological requirements. Both species are concentrated on the sanctuaries. In Marion County, although relative stability was maintained from 1963 through 1979, a definite high in 1982 was in synchrony with the combined prairie chicken-pheasant population at Bogota and population highs in Wisconsin and Minnesota. Thus, cycles may indeed be natural phenomena to be considered. Over a decade, abundance can be expected for several years — typically in





Two graphs show the fluctuations in the counts of prairie chicken and pheasant cocks only on two separate sanctuaries. Counts for cocks and hens are usually about 50-50.

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years ending in 1, 2, or 3 — but relative scarcity must also be expected about half the time — typically in years ending with 6, 7, or 8.

Currently, two scatter-patterns of sanctuaries totaling 1,920 acres (14 separate tracts) in Jasper and Marion counties are managed cooperatively by the Survey, the Illinois Department of Conservation, and The Nature Conservancy. Although sanctuary acquisition began in 1962, a good test of the density of prairie chickens that can be maintained through so-called cyclic lows did not occur until the 1976-1978 period. By that time, a stabilized program of sanctuary management was underway in both counties. The two populations did not show simultaneously clear troughs in 1976-1978, but their numbers were relatively low. The prairie chicken densities then were essentially identical in both counties — 70 cocks per square mile of nest cover (on sanctuaries). On average, densities of 100 prairie chicken cocks per square mile of nest cover appear realistic for Illinois (perhaps the highest in the range of the species). During cyclic highs, the density may be 2 or 3 times that of the density at cyclic lows.

The data on cycles, densities, and possible thresholds suggest an acreage goal of 1,500 acres in each of two areas of Illinoi of which about 75 percent might realist cally provide quality nest cover on a annual basis. Such an acreage could be e pected to support 200 prairie chickens du ing cyclic lows, an average of 300 bird and up to 600 grouse at cyclic highs. Thes population sizes would range from 4 to 1 times the supposed extinction threshold c 50 birds and provide a measure of safet against such factors as pheasant compet tion, oil development activity, heavy pre dation of nests on the sanctuaries, and in creasingly intensive land use around th sanctuaries.

Thus, an additional 1,000 acres of sanc tuaries should be added to the presen systems. Because of the success of Illinois scatter patterns and the historically poo "track record" of single, large refuges i Illinois and in other states, new sanctuarie should also be scattered. Sanctuaries ma range from 80 to 160 acres or more in size and not be more than about 1 mile apart Better management of existing sanctuaries is also a critical need. Hopefully, Illinois new nongame wildlife check-off progran will provide funding to help meet management needs of the prairie boomer and other components of our prairie ecosystem.

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NATURAL HISTORY SURVEY REPORTS

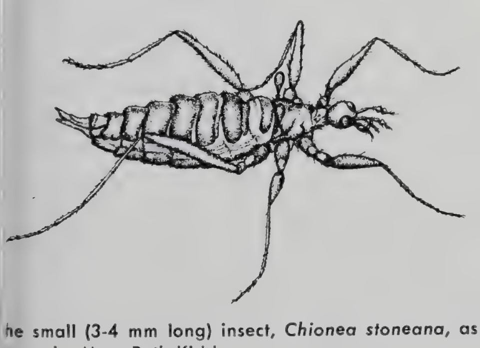
APRIL 1984, NO. 240

's a Snow Fly!

In winter few people expect to see in-:cts crawling about on the snow, but Sur-:y biologists, John Unzicker and Allison righam, are studying the biology of a ingless fly that does just that. A member f the forest litter community in Illinois, iis small (3-4 mm long) insect, *Chionea oneana,* is active on the snow at tempera-ıres as low as 10°F (−12°C).

Since invertebrate animals are cold-looded (poikilotherms), keeping active uring winter is important to the sur-ival of insects like *Chionea*. This dark-olored fly can be seen walking on snow ı woodlands from mid-November through arly February. *Chionea* belongs to an ar-ıropod community active in the forest tter layer under winter's snowy blanket ıat includes other animals such as beetles, piders, mites, gall-making wasps, scorpion-ies, centipedes, millipedes, and springtails.

The genus *Chionea* in North America ccurs in relatively dry oak-hickory forests, ıorthern beech-maple associations, and the ıixed deciduous and evergreen forests of astern Canada. In the western mountains, *'hionea* may be found from the lower dry orests of ponderosa pine up through the zone of lodgepole pine, and into the high alpine forests of spruce and fir.



he small (3-4 mm long) insect, *Chionea stoneana,* as rawn by Mary Beth Kidd.

Adult *Chionea* appear during the cold months of the year, mate, disperse, with females laying eggs in the forest litter or on the soil surface beneath the litter. The eggs apparently take 1 or more months to hatch. The wingless condition of these flies is utilized in an interesting way. Gravid females hold eggs in the thorax as well as in the abdomen. Since these insects lack wings, the thorax is not packed with large flight muscles. Therefore, the space in the thorax can be used as additional storage space for eggs. The larvae of *Chionea stoneana* grow throughout the warm months of the year, with pupation occurring at the end of the summer or in early autumn. Adult emergence begins in mid-November, completing the cycle.

Little else is known about the activities of this fly in the litter-soil surface layer because it blends in with the drab colors of the twigs, leaves, and bark that constitute most of the plant biomass of this layer. The snow layer on the soil protects the animals living in the litter layer and on the soil surface. A 6-inch layer of snow will keep the soil surface up to 15°F warmer than the air above the snow.

As the snow melts exposing the bases of trees and other woody vegetation during "warm spells," openings or channels occur in the snow through which animals can escape to disperse throughout the woodland. *Chionea* have been seen to walk in a straight line as far as 100 feet on the surface of the snow.

The activity of this winter insect on the snow is limited by light intensity, temperature, and blowing snow. They are most

active during calm, sunny days when air temperatures reach 40°F (4.4°C) or more. *Chionea* avoid the lethal effects of freezing temperatures during cold weather by a process called *supercooling* or lowering the freezing point of their body fluids.

Unzicker and Brigham have studied these insects over three winters at two woodland sites in east-central Illinois to determine their distribution and population densities and to understand other aspects of their life cycle. Climatological data were recorded, including maximum-minimum air temperatures (above ground, at ground level above the litter layer, and at the soil surface under the litter layer), precipitation, and sky conditions. Additional studies planned for recent winters to characterize *Chionea* genetically have been hampered by unusually warm weather that restricts the activity of these winter-hardy insects!

Arbor Day — A Holiday of the Future

In many countries, it has long been the tradition to hold a tree or forest festival annually. The origin of such celebrations must date back to antiquity, according to E. B. Himelick, plant pathologist at the Survey.

But the idea of calling a special day Arbor Day, as it is commonly known today throughout the world, evolved from the idea of one man living in the Great Plains of the United States. The idea spread widely to other countries where today it is variously celebrated as the "Festival of Trees," "Greening Week" in Japan, "The New Year's Day of the Trees" in Israel, the "Tree-Loving Week" in Korea, the "Afforestation Week" in Yugoslavia, the "Students Afforestation Day" in Iceland, and the "National Festival of Tree Planting" in India. Arbor Day, in its various forms, is now recognized in more than 50 countries.

The first Arbor Day was observed in the state of Nebraska on April 10, 1872. More than 1 million trees were planted in Nebraska on that day. During the 1870's, other states passed legislation to observe Arbor Day. Several United States presidents have proclaimed a national Arbor Day, but many states, because of different climatic zones, continue to celebrate the

The tulip tree pictured is a good tree for Arbor D planting. It is decorative in early spring and giv good shade in the summer. Disease resistant, it is sturdy, durable tree, and it grows quickly.

holiday at different times of the year. Mo states observe the holiday on the last Frida of April, as we do in Illinois. Some do the actual tree planting on the state's own Ar bor Day, which varies from January t February in the southern United States t May in the northernmost states.

The idea of Arbor Day was conceive by J. Sterling Morton, then a member c the Nebraska State Board of Agricultur He was a journalist and became editor c Nebraska's first newspaper. Through hi articles, he provided information on th use of trees and his suggested planting da to be called Arbor Day.

J. Sterling Morton was tirelessly enthusi astic about planting trees. He realized tha although the Great Plains were essentiall treeless, they had the climate and the soil favorable for tree growth. His articles wer about trees which were best suited to th area, and he encouraged the settlers t plant trees around their homesteads. Mor ton also advocated tree planting by schools civic organizations, and groups of ever kind.

The earliest recorded celebration of Ar-
or Day involving school children occurred
ı April 27, 1882. On that day, 21 trees
ere planted in Eden Park in Cincinnati,
)hio; one for each United States presi-
ent up to that time. The first tree planted
as a white oak, in memory of George
Vashington. Approximately 30,000 per-
ons attended the tree planting. Schools
t out, businesses closed, and many promi-
ent persons attended. Eden Park now has
n area called Presidents' Grove.

J. Sterling Morton, upon learning of the
rbor Day celebration in Cincinnati, was
elighted to learn of the involvement of
chool children in planting trees on that
ay. Morton considered the adoption of
rbor Day by schools the most important
spect of the holiday's development. Mr.
Morton died in 1902. One of his favorite
ayings adorns a memorial marker to him
n Nebraska City, Nebraska: "Other holi-
lays repose upon the past; Arbor Day pro-
oses for the future." Celebrated by chil-
lren, Arbor Day is becoming a holiday of
he future, for when a child plants a tree,
ıot only is work done for which the com-
nunity might benefit, but also for which
ıe or she, in later years, might benefit.

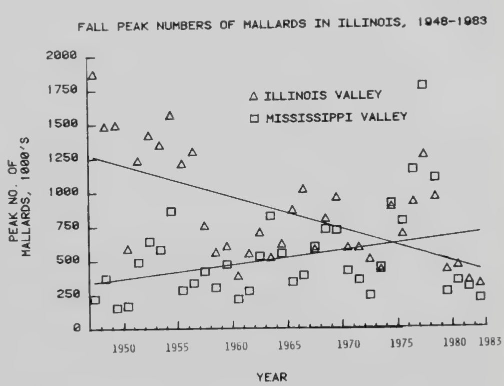
Probably one's first unconscious reaction
o a community is caused by the absence
or abundance of trees. It is frequently said
hat no single item distinguishes one city
or town from another more than its green
ıreas and streets lined with trees.

Trends in Mallard Numbers in Illinois

Each fall, thousands of waterfowl pass through Illinois enroute from their summer breeding grounds in Canada and the northern United States to their wintering grounds in Arkansas, Louisiana, Mississippi, and the Gulf Coast. Because Illinois lies between the breeding and wintering grounds for waterfowl in the Mississippi Flyway, it provides critical migration habitat for several species. Each day spent in Illinois during the fall migration provides waterfowl with an opportunity to rest and feed, and thereby to maintain their physiological condition at a level that will allow further migration. Days spent in Illinois also reduce the duration of stay on the wintering areas and, therefore, the amount of food that the wintering areas must provide.

Stephen P. Havera and Frank C. Bellrose, along with the staff of the Havana Field Station, are currently investigating the abundance and distribution of waterfowl throughout Illinois during the fall migration. Bellrose initiated the aerial inventories of the Illinois and Mississippi river valleys in 1948, thereby providing us with 36 years of continuous information on the waterfowl use of the rivers. Survey researchers believe that these inventories are the longest continuous series of waterfowl censuses in the United States. In 1971, Robert Crompton assumed the responsibilities of aerial censuses which have been expanded recently to include wetlands and rivers in northeastern, northwestern, central, and southern Illinois. Thus, although every duck that passes through Illinois each fall is not counted, there is a yearly index available of the numbers of approximately 20 species of waterfowl to use for comparison of trends in abundance, distribution, and chronology of migration.

The number of ducks that arrive at fall migration areas and the duration of their stay is determined by several factors. These factors include the size of the breeding population in the spring, the habitat and weather conditions on the breeding grounds, the conduciveness of weather conditions to migration along the flyway in the fall, and the amount of food and the presence of refuges on the migration areas. With this information, the long-term



Peak numbers of mallards censused each fall in Illinois and Mississippi River valleys, 1948-1983.

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trends of waterfowl use for these major migration sites can be examined.

In recent years, mallards have constituted approximately 50 percent of the nearly 400,000 ducks harvested annually in Illinois. In addition, mallards have represented about 86 percent and 47 percent of waterfowl use of the Illinois and Mississippi rivers, respectively, since 1960.

The highest number, or peak number, of mallards counted at any one time during the fall migration each year from 1948 to 1983 for the Illinois and Mississippi river valleys is shown in the accompanying figure. The Illinois River has always accommodated more mallards than the Mississippi River, but the difference in numbers is becoming smaller. The 10-year averages of the peak numbers of mallards counted for 1950-1959, 1960-1969, and 1970-1979 are 1,126,200; 652,800; and 767,400; respectively, for the Illinois River as compared to 440,300; 490,700; and 562,100 for the Mississippi River during the same periods. For the 1980-1983 period, however, the average of the peak number of mallards for both rivers has been substantially lower, averaging 374,500 for the Illinois and 277,800 for the Mississippi. The reduced numbers of mallards counted since 1980 are a reflection of the low level of the mallard breeding population and droug conditions on the breeding grounds. T peak number of 307,600 mallards in 19 for the Illinois River was the lowest nu ber ever counted since the inventories b gan in 1948. Similarly, the 1983 malla peak of 212,200 for the Mississippi Riv was the lowest counted since 1950.

A comparison of the downward tre of mallard numbers using the Illinois Riv and the stable-to-slightly-upward trend mallards inventoried on the Mississip River can be explained by the waterfo habitat associated with each river. In t Illinois River valley, wetlands have bee degraded by sedimentation which h greatly reduced the variety and abundan of aquatic plants and other natural foo available to mallards.

In addition, the popularity of plowin harvested corn fields in central Illinois du ing the fall has sharply decreased the was grain resource for mallards. By contras the aquatic plant life of the Mississip River thus far has been less affected b sedimentation. Moreover, several publi areas and refuges have been establishe during recent years in key locations alon the Mississippi and these sites are bein effectively managed for waterfowl.

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NATURAL HISTORY SURVEY REPORTS

MAY 1984 NO. [illegible]

ciety for the Illinois Scientific Surveys

The Natural History Survey, the Geo-gical Survey, and the Water Survey have st initiated a not-for-profit corporation titled the Society for the Illinois Sci-tific Surveys (SISS). Chief Paul Risser om the Natural History Survey is the first ecutive secretary, and a full board of rectors is presently being appointed. As e society develops during the coming ar, membership opportunities will be-me available, a publication will be pro-ıced, and several interesting field trips ıd educational activities will be presented.

The purpose of the society is to offer a eans for more Illinois citizens to recog-ize, understand, and appreciate the state's atural resources by (a) providing infor-ıation that is technically sound but com-rehensible by the layperson, (b) orga-izing activities through which natural sources can be observed and discussed, c) making programs of the three sci-ntific Surveys widely known, and (d) urturing various processes that permit the itizens of the state to supply data, infor-ıation, and materials to the scientific urveys. In a broad sense, the purpose of he society is to enhance the wise use and ıanagement of the natural resources of llinois through support of the activities nd programs of the three scientific urveys.

Plans for the publication are not yet omplete, but possible articles include the ollowing:

(1) feature stories on topics of specific interest;
(2) feature series on topics of general interest, e.g., urban deer problems, contamination of aquifers, earth hazards (landslides, earthquakes, mine subsidence, etc.);
(3) monthly short information items such as pictures and descriptions of birds or spiders most likely to be seen, or the supply/demand outlook for Illinois' mineral resources;
(4) in-depth discussions, with data, about topics treated more superficially in the newspapers, e.g., erosion of Lake Michigan shores, better utilization of Illinois coal;
(5) commentaries about natural resources issues by well-known individuals in the state, e.g., governor, legislators, members of advisory boards;
(6) letters to the editor;
(7) a column where readers can ask questions to be answered by the Surveys' staffs; and
(8) a directory where specific services or information may be obtained.

Periodically, individuals and businesses wish to make contributions to the Surveys in the form of money, equipment, or property. Since the society will have a tax-exempt status, such gifts can now be received in a manner which benefits these donors.

The activities of the society will not replace the Surveys' responsibilities to the state. Rather, the society will assist the Surveys in dispersing information to the citizens of Illinois and elsewhere, and in providing a greater educational role for all three Surveys.

Winter Diving on the Mississippi River

What do river fish do in the winter time? How susceptible are these fish and

their habitats to disturbances from dredging activities or winter barge traffic? Until recently, river biologists have only speculated on the answers to these questions. In January, however, Survey biologists from the Grafton field station cooperated with other state and federal agencies and commercial divers to make first-hand observations under the ice cover of the Mississippi River, a first vital step to answering the above questions.

Visual observations of the bottom of the river are possible only during the winter, when water clarity extends beyond 2 or 3 feet. Ken Lubinski led the research team that compiled 20 hours of "down time" at five sites on Navigation Pool 13, Mississippi River, between Belleview, Iowa, and Savanna, Illinois. Most of the dives were made by Robert Anderson, Great Lakes Consultants, Inc., out of Traverse City, Michigan. Dives averaged about an hour in length.

The divers used specially designed drysuits for thermal protection. Air was supplied by large-volume tanks on the surface of the ice connected to the diver's helmet by an umbilical cord. At each site, groundlines were deployed to guide the diver and provide reference points for his observations, which were communicated by microphone wires to the surface where they were recorded in a dive log. Still photographs and video tapes were also made.

Of the five main channel sites explored, two had been used previously as experimental thalweg (the deepest part of channel) disposal sites by the U.S. Corp Engineers. At these sites, dredged mater mostly sand, was removed from ar where it might impede navigation a deposited in the thalweg.

Several unexpected observations w made by the dive team. Rather than be uniformly barren sand flats and dur as was previously thought, three of the f sites (including one disposal site) turn out to have mixed substrates of gravel a cobbles and supported large numbers mussels. Large concentrations of dorma flathead catfish, ranging from 2 to pounds, were observed seeking shelter and around log piles at two sites. Otl fish species included channel catfish, l perch, silver chub, gizzard shad, sil lamprey, and shovelnose sturgeon. At t edge of one disposal site, deposited sa graded immediately into large numbers mussels on firm substrate, indicating tl some mussels, as well as periphyton a aquatic insects, had probably been buri during disposal.

The observations suggested that catf and shovelnose sturgeon, because of th dormant behavior, would be the m susceptible species to winter disturbanc The variety of habitats, substrates, a organisms observed resulted in a recon mendation to survey or sample future si before disposal to eliminate any chance burying aquatic populations or valuab habitats under sand.

Robert Anderson, principal div prepares to descend to the bott of the Mississippi River. Assisti him are Tim Adamsky and Gr Busch.

irds and Woodlots

Reduction of total forest area and the ragmentation of native forest into isolated atches have affected populations of many ird species adversely, especially those ongbirds that winter in the tropics. Be-ause forest habitat is also disappearing at n alarming rate in Latin America where hese birds winter, there is an urgent need o determine the area requirements of hose species that depend on forest interior abitat.

In a study funded by the U.S. Fish and Wildlife Service, researchers at the Uni-versity of Illinois, Department of Ecology, Ethology, and Evolution, studied birds in 15 woodlots in east-central Illinois. Their goals were to determine how many species disappear as the area of woodlots decreases and what species are least able to maintain populations in small woodlots.

After censusing bird populations, John Blake and James Karr (who has an affili-ate appointment at the Natural History Survey) showed a strong correlation be-tween area of woodlot and number of breeding species. A 1,500-acre woodlot supports about 40 species of breeding birds. At 100 acres, only 30 species remain and 5-acre woodlots support only 10 to 15 species.

Species that winter in Central and South America seem especially susceptible to local extinction in the face of habitat fragmen-tation. In contrast, numbers of permanent residents and, especially short-distance migrants, were not strongly correlated with forest area. Short-distance migrants gen-erally do not require forest interior habitat for breeding, and they are not as likely to suffer population reductions following forest fragmentation. These findings are similar to those reported from the Middle Atlantic states in 1979.

Many warblers, vireos, thrushes, gnat-catchers, tanagers, and flycatchers are among the neotropical migrants most de-pendent on large tracts of forest for nest-ing. Examples of the smallest tract on which birds were found during the breeding season in east-central Illinois are 1,500 acres for the hooded warbler; 290 acres for the American redstart; 160 acres for the Cerulean warbler; 70 acres for the Acadian flycatcher, the blue-gray gnatcatcher, the northern parula, and the ovenbird; and 40 acres for the scarlet tanager.

Although these species defend territories of only 2 to 5 acres during the breeding

Small woodlots such as this one in southern Piatt County, Illinois, are essential to the preservation of vanishing species of birds.

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season, a block of forest many times that large is needed to attract even small populations of these area-sensitive species. This concept must be taken into account in planning the acquisition and management of natural areas.

Much controversy over optimal size of natural areas has centered on the importance of small reserves and, in particular, whether two or more reserves equal in total area to a single large reserve will support more or fewer species. Despite inherent differences in species' biologies, few analyses of species occurrence in large or small forests have adequately addressed species composition (as opposed to species number) in relation to forest area. Consequently, many arguments over reserve size have not addressed a central purpose of many parks and reserves; that is, the preservation of species that are most at risk of extirpation or extinction. Blake and Karr used data from east-central Illinois to examine the relative benefit of multiple and small reserves versus single and large reserves. Although two small forests may, in some cases, hold more total species than a larger one, a single large reserve will preserve more of those species that are mo
dependent on forest interior habitat; th
is, those species that are most at risk. Ma
agement strategies, to be most effectiv
must focus on species most in need of co
servation efforts.

The conservation value of woodlots i
highly disturbed landscapes such as eas
central Illinois extends beyond the bree
ing season. During migration, many speci
pass through Illinois on their way t
northern breeding grounds or souther
winter grounds. Because migration is a
energetically expensive activity, birds mu
be able to periodically replenish energ
supplies. Because agricultural land pr
vides little adequate habitat for most m
grants, the presence of natural patches c
habitat, such as woodlots, can be of grea
benefit. In many cases, species that bree
only in very large woodlots use even sma
patches of forest during migration fo
foraging and resting. Large woodlots sup
port greater numbers of species and ind
viduals, but during spring and fall migra
tory periods, woodlots of almost any siz
provide valuable habitat for many specie

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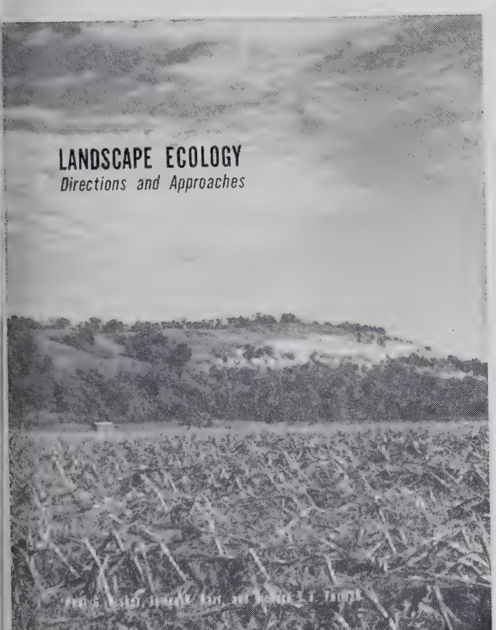
NATURAL HISTORY SURVEY REPORTS

JUNE 1984, NO. 238

Special Publication On Landscape Ecology

"In recent years a new field of science, called regional ecology or landscape ecology, has been emerging. Current ideas about landscape ecology are influenced by the theories, methods, and points of view of a number of scientific disciplines, and these influences appear to have stalled the crystallization and communication of the current understanding of landscape ecology, especially as the concept might facilitate basic and applied research on natural resources." So wrote the authors of a recently published report titled, *Landscape Ecology: Directions and Approaches,* Illinois Natural History Survey Special Publication Number 2.



Cover of new special publication on landscape ecoolgy (Photo by R. A. Evers).

One method of speeding the integration of a landscape ecology approach was to gather together experienced individuals with different viewpoints but with a strong desire to examine landscapes through the ideas of ecology and related disciplines. With funding from the National Science Foundation, Dr. Paul G. Risser, Chief of the Illinois Natural History Survey, called together 24 other scientists for a workshop meeting on landscape ecology, to evaluate the potential of such a discipline, and to describe its application to basic and applied natural-resource issues.

Dr. Risser and two of the other project directors, Dr. James R. Karr of the Department of Ecology, Ethology, and Evolution, University of Illinois, and Dr. Richard T. T. Forman, Department of Biological Sciences (Botany), Rutgers University, took the materials of these meetings and fashioned them into a coherent series of statements about the scientific research approaches being used and the directions which research might take in the new field of landscape ecology.

Early in the report the authors point out that "Landscape ecology differs from subdisciplines of ecology, such as population, community, and ecosystem ecology, in matters of primary emphasis. Landscape ecology focuses explicitly upon spatial pattern. Specifically, landscape ecology considers the development and dynamics of spatial heterogeneity, spatial and temporal interactions and exchanges across heterogeneous landscapes, influences of spatial heterogeneity on biotic and abiotic processes, and management of spatial hetero-

geneity." They go on to say, "Principles of landscape ecology help to provide theoretical and empirical underpinnings for a variety of applied sciences, e.g., regional planning, landscape architecture, and natural-resource management."

Copies of this report may be obtained from the Illinois Natural History Survey, Natural Resources Building, 607 East Peabody Drive, Champaign, Illinois 61820.

Information System Being Developed

A computer-based natural resource information system is being developed at the Natural History Survey. The system contains data on the biological, geological, and hydrological resources of Illinois as well as cultural resources (anthropology and historical sites) and social and economic data. The system is a cooperative effort between five divisions of the Department of Energy and Natural Resources: Energy and Environmental Affairs, the Natural History Survey, the Geological Survey, the Water Survey, and the State Museum. A large amount of funding for the system has come through the Lands Unsuitable for Mining Program sponsored by the federal office of surface mining.

The natural resource information system is an important new research tool and a significant advancement in the management of natural resource data. It will stimulate new directions in research by allowing scientists to synthesize, analyze, and display large amounts of data within a geographic context. For example, researchers will be able to model the potential for insect infestations, habitat loss, mine land reclamation and other threats to natural resources. The relationships between factors such as vegetation and soil may be studied on a regional as well as a local scale. The system will also be used to maintain detailed inventories of the state's natural areas, streams, wetlands, and forests. Comprehensive data files are being compiled on the distribution and chacteristics of Illinois' fish, wildlife, and plants. Computer access to the data will allow responses to the public's need for natural resource data to be more timely and complete than what is now possible using manual methods. As a central reposito the system will improve archival stora and sharing of natural resource data.

The system is being developed on Prime 750 minicomputer located in t Natural Resources Building in Champaig Communication lines give all five Ener and Natural Resources divisions dire access to the system. Each division equipped also with a graphics work st tion to be used for data entry and analys A graphics work station consists of digitizer and a graphics terminal. A dig tizer is a special device resembling a lig table and is used for encoding map info mation. The graphics terminal is a TV-li device used to display the data once it h been entered into the computer. The sy tem has three pen blotters which can pr duce maps and other graphics in fo colors at speeds up to 18 inches per secon A colorgraphic recorder is available produce color slides or 8 x 10 prints. Th system has been under development f almost 2 years. Computer operations bega in September 1983. Recent efforts hav been concentrated on training staff an installing data on the system.

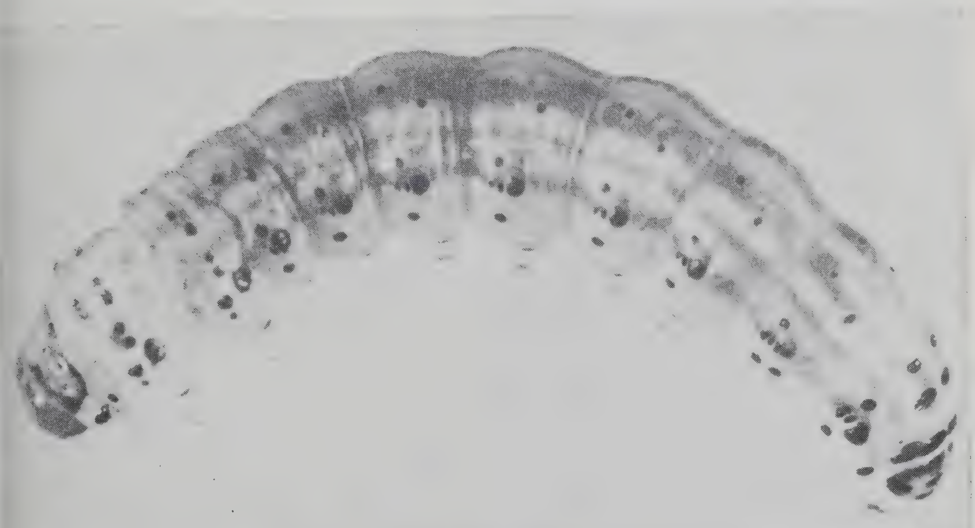
It's Boring

Survey entomologists studying corn i sects were baffled for several years by "mystery" borer that sporadically was d tected in the stems of young field corn the northern one-third of Illinois. Th caterpillar was first noticed in Kane Coun during July 1978 and as far west as Carro County in subsequent years; and Wiscons researchers recently have seen it in Man towoc County of that state. Efforts identify the caterpillars were unsuccessf until a single specimen was reared to th moth stage in 1983 by entomologists Georg L. Godfrey and Eli Levine. The mot proved to be *Amphipoea americana* Speye a moderately common species but whos caterpillar has not been described.

The caterpillar of *A. americana* is ve similar to the hop vine borer, *Hydraeci immanis* Guenée, which was discussed i *Survey Reports* No. 196 (April 1980) an described along with the potato stem bore *H. micacea* (Speyer), in Illinois Natura

istory Survey Biological Notes No. 114 ʼebruary 1981). Similarities include physal appearance and the same geographical stribution (in Illinois). Another species ith which it may be confused, at least in ıe earlier larval stages, is the stalk borer, *apaipema nebris* Guenée (see *Survey Report* No. 228 (June 1983).

Levine hypothesizes that acreages of orn planted using reduced tillage practices ıay result in increased populations of *A. mericana*. Published information on this pecies is very meager, and it is impossible ɔ ascertain the species's potential economic significance until the basics of its life history and host plant preferences are understood. Therefore, Levine is planning to study its ecology feeding damage on corn in 1984 to clarify the situation. Godfrey will be supporting the work by assessing morphological characters that may be used by other researchers to help distinguish *A. americana* caterpillars from other corn boring caterpillars. Persons suspecting that they may have this species are encouraged to contact either Godfrey or Levine at the Survey (see the address on page 4 of this issue).



Mature caterpillar of *Amphipoea americana* 25 mm in length (Photo by G. L. Godfrey).

Mature caterpillar of the hop vine borer, *Hydraecia immanis*, 30-35 mm in length (Photo by G. L. Godfrey).

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NATURAL HISTORY
SURVEY REPORTS

VILLIAM LUCKMANN COMPLETES 5 YEARS OF PUBLIC SERVICE

Dr. William H. Luckmann
(Photo by Les Woodrum)

Dr. William H. Luckmann retired from he Illinois Natural History Survey on ugust 31 after serving as Entomologist nd Head of the Section of Economic Enomology since 1965. Dr. Luckmann began is long career at INHS as a research ssistant in the Section of Economic Entonology in 1949.

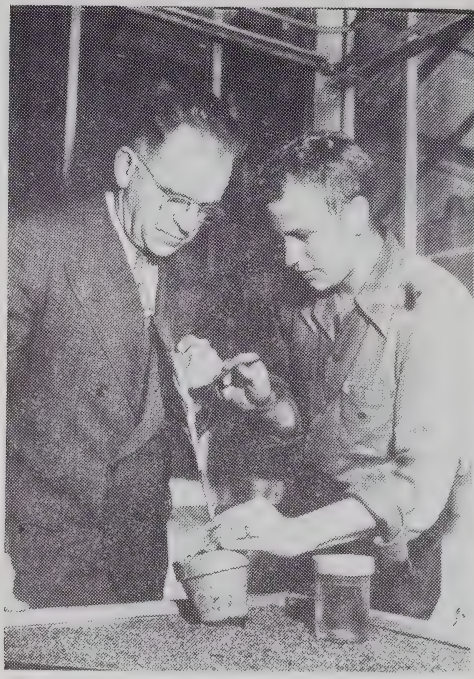
Dr. Luckmann's chief research interests ave been in corn entomology and the enironmental impact of pesticides. In the ield of corn entomology, he has been articularly concerned with the European corn borer, the corn rootworms, and the lack cutworm, insects of overwhelming consequence to producers of corn in Illiois. His work on the environmental impact of insecticides has manifested itself in the monitoring of pesticide residues in crops, soil, and wildlife. He has been particularly concerned that Illinois agricultural producers not find their products unmarketable because of residues.

Dr. Luckmann's research endeavors have led to the formation of effective pest-management programs that serve to maximize crop protection with minimal environmental disruption.

Through the medium of the widely accepted book *Introduction to Insect Pest Management* that he co-edited with Dr. Robert L. Metcalf, he reached large numbers of students and crop protection specialists here and abroad with his philosophy of modern pest management.

In his administrative role, Dr. Luckmann structured his staff into effective teams of researchers that have enjoyed considerable success in combating the pests of corn, soybeans, alfalfa, fruit crops, ornamental plants, and vegetable crops. He has also encouraged his staff to become involved in international programs in agriculture in the certain knowledge that a broader base of experience would help in solving the problems confronted by Illinois agriculture, and he himself studied and consulted in India, Iran, and Puerto Rico.

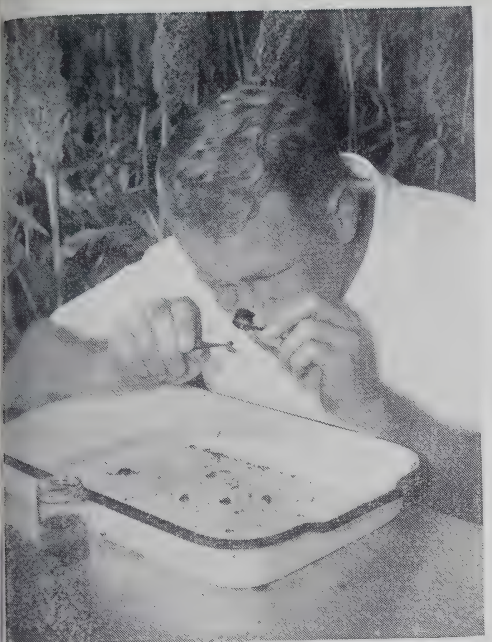
Dr. Luckmann's leadership in research, administration, and education has gained him national and international recognition. He served as President of the North Central Branch of the Entomological Society of America in 1978 and 1979. From



A young Bill Luckmann working on corn borer research with Dr. George Decker. It was part of Luckmann's thesis in March 1950 (photo by C. L. Scott).

Dr. Luckmann using hand sprayer on corn earworm 1952 (photo by W. E. Clark).

Sitting on commercial sprayer, he is again spraying for corn earworm near Rochelle, Illinois in 1952 (photo by W. E. Clark).



Sorghum plant heads are examined for insects. Picture was taken in 1957 (photo by W. E. Clark).

In 1964 he was releasing Tiphia wasps, parasites of the Japanese beetle.

Section Heads meet with Dr. George Sprugel in 1967. Dr. Luckmann is on the far left. Left to right are Dr. Herbert Ross, Faunistic Surveys and Insect Identification; Dr. George Bennett, Aquatic Biology; Dr. Cedric Carter, Botany and Plant Pathology; and Dr. Glen Sanderson, Wildlife Research (photo by W. D. Zehr).

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Clarence White and Luckmann release ladybugs in corn and alfalfa fields in 1975 (photo by Larry Farlow).

1977 to 1979, he was Chairman of the Pesticides Subcommittee of the Task Force on Agricultural Nonpoint Sources of Pollution. He is listed in *American Men an Women of Science* and *Who's Who i America.*

A native of Cape Girardeau, Missour he began his long career at INHS as a re search assistant in the Section of Economi Entomology in 1949. He received an ap pointment as Assistant Entomologist a INHS in 1951, the year that he receive his M.S. degree in entomology from th University of Illinois. In 1954 he was pro moted to Associate Entomologist, and years later he received his Ph.D. degree i entomology from the University of Illinois He was promoted to Entomologist at INH in 1959.

In addition to his appointments a INHS, from 1965 until his retirement h served as Head of the Office of Agricul tural Entomology in the College of Agricul ture at the University of Illinois and a Professor of Entomology in the Departmen of Entomology of the School of Life Sciences at the University of Illinois.

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NATURAL HISTORY
SURVEY REPORTS

OCTOBER 1964, NO. 140

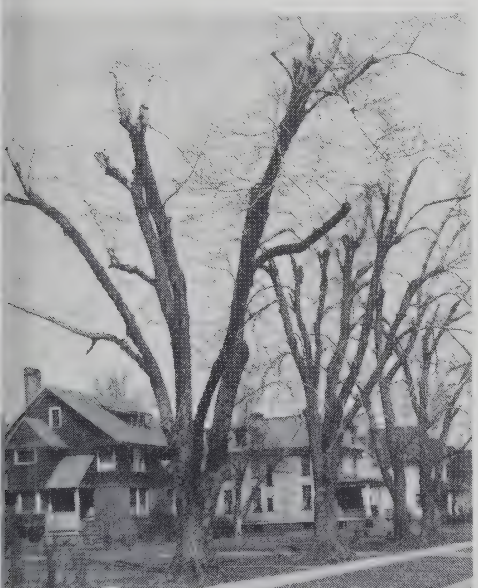
runing Shade Trees

Trees must receive regular maintenance ›r rapid growth and good health, accord- g to E. B. Himelick, Survey plant pa- ologist. Such maintenance includes water- ıg, fertilizing, pruning, spraying with ›sticides, surgery, bracing and cabling, ·eventing grade changes, and protecting gainst chemical and lightning injury. roper pruning is often neglected for too ng and trees become hazardous and re- ıire extensive corrective measures.

Magnificent trees of almost every species ·own on the home grounds are deformed y "local talent" tree trimmers. Himelick ıys these trimmers, through ignorance or ıe need for an extra dollar, tend to cut ıtire tree tops or sides of the crown, leaving only the trunk and large stubs. Such trees are either killed outright or, if they survive, produce vigorous sucker growth with short-lived crowns and ugly form. The stubs left by this practice will eventually decay and produce only a shell to support future growth of large branches.

Pruning should be done by an experienced arborist with on-the-job training, proper equipment, and one who is familiar with the techniques and hazards of working on large trees. The use of climbing spurs or irons is not recommended and should not be used on living trees.

Crown reduction should be done on a continual basis to avoid extensive pruning any one year. The growth habit of a particular species dictates how the tree should be pruned.



ccessive pruning by severely cutting back all major ranches frequently results in dying back of the in- red branches (photo by Ray Hamm).

Extensive pruning of large branches or leaders usually results in the production of thick masses or clumps of slender, weak branches (photo by Ray Hamm).

There are four types of pruning: fine, medium, coarse, and drop-crotch. Fine pruning is the most extensive and includes the removal of dead, dying, diseased, and interfering branches and selective thinning to decrease wind resistance. Medium pruning is similar but generally is a less severe type of pruning. Coarse pruning consists only of removing dead and weakened branches 2 inches in diameter and larger. Drop-crotch pruning consists of top and side reduction through the selective removal of vertical and lateral branches. All pruning cuts should be made close to the trunk or parent limb, without cutting into the branch collar or leaving a protruding stub, so that bark-callus closure can develop. When done properly, this type of pruning involves cutting branches back to lower lateral branches having at least one-third the diameter of the branches removed.

Drop-crotch pruning is used when branches interfere with utility lines, when major branches or root systems are severely damaged, or when unusual and rapid branch growth in the tops or sides of tree crowns occurs. This type of pruning may be required periodically on fast-growing trees such as silver maple, Siberian elm, and willow. Drop-crotch pruning is basic to any pruning operation and is used to reduce the height and spread of the crown while retaining its natural shape.

Tree crowns are sometimes pruned or thinned to increase the vigor of remaining branches. Opening the crown permits more light penetration and stimulates lateral bud growth. Selected removal of excessive succulent growth will encourage the development of strong branching laterals and increase the general vigor of crown development.

Judicious pruning of trees with weakened branches or damaged root systems will lessen wind resistance and weight of the crown. Thinning and drop-crotch pruning requires both skill and time and if done correctly, it will benefit both the tree and its aesthetic appearance. The best compliment an arborist can receive after major pruning is having the average person fail to notice a tree has been pruned. Pruning standards published by the National Arborist Association offers general guideli followed by most arborists.

Homeowners should be aware of the sponsibilities they have in the preservati of their trees. Old trees that decline a have weak and dead branches can often kept healthy for many years through pro pruning. Wood-chip mulch, fertilizatio proper watering, and disease and pest co trol practices will also be beneficial in pr longing the life of a valuable tree. Mu thought should be given to proper tr selection and planting location to avoid t expense of extensive corrective pruni years later.

Food, Fiber, and Fugitive Insects

Among the many specimens submitted systematists of the Illinois Natural Histo Survey for identification during 1983 we two species of insects and one of an inse ally, a tick, which represents first detectio for the state.

The newcomers included two species long-horned beetles which breed in de and dying pine trees. These beetles a potential carriers of the pinewood nem tode, a causative agent of pine wilt whi has been very destructive to pines in Il nois in recent years. The newly detect tick is of veterinary importance and, addition, is believed to be a cause of ti paralysis in man. Two of the migran undoubtedly moved into Illinois from a jacent states, and one was seemingly intr duced from overseas.

The phenomenon of the active dispers and passive transportation of pest speci of insects into Illinois from neighbori continental areas and from elsewhere well-known and obviously continuin Readers of *Illinois Natural History Surv Reports* will be aware of such examples the alfalfa weevil, the imported crucif weevil, the western corn rootworm, an the gypsy moth. A recent estimate of th Entomological Society of America numbe the major and minor pest species that hav been introduced into the borders of th United States to be more than 800. Ac cording to that study, among the importe species are a number of serious pests whic

collectively are responsible for over 50 percent of all insect losses in the United States.

The migration of pest species from outside the state is not a recent development in Illinois. Benjamin Walsh, a pioneering entomologist who became the first State Entomologist of Illinois in 1867, wrote an article on the subject of imported and migrating insects as early as 1866. Writing from Rock Island, he stated that fully one-half of the worst pest species known in America at that time were known to have been imported from Europe. Walsh was also familiar with range adjustments in native insects. In documenting the arrival of the Colorado potato beetle in Illinois in 1864, he noted that it was the first record of a pest species spreading from the western United States to the east. All previous importations and migrations had been from the east. An interesting example of an insect that arrived in Illinois from the south is provided by the boll weevil. Although the boll weevil was detected in Illinois several decades ago, the fact is little known even among entomologists because of the minor extent of cotton production in Illinois.

Because of the continuing arrivals of new pest species in the state, crop protection specialists in Illinois face a difficult task. As resident pests are studied and brought under scientific management, new pests arrive on an almost yearly basis. The systematists of the Illinois Natural History Survey work to insure that these invaders will be promptly and correctly identified upon their first detection in the state.

Years of first detection in Illinois of some insects and insect allies of economic importance.

1938 JAPANESE BEETLE, *Popillia japonica* Newman (on ornamentals)
1939 EUROPEAN CORN BORER, *Ostrinia nubilalis* (Hubner)
1940 IMPORTED LONGHORNED WEEVIL, *Calomycterus setarius* Roelofs
1953 JAPANESE BEETLE (on field crops)
1957 MIMOSA WEBWORM, *Homadaula anisocentra* Meyrick
1959 FACE FLY, *Musca autumnalis* De Geer
1959 BROWN RECLUSE SPIDER, *Loxosceles reclusa* Gertsch & Mulaik
1963 SOUTHWESTERN CORN BORER, *Diatraea grandiosella* (Dyar)
1964 ALFALFA WEEVIL, *Hypera postica* (Gyllenhall)
1964 WESTERN CORN ROOTWORM, *Diabrotica vergifera vergifera* LeConte
1965 AZALEA LEAF MINER, *Caloptilia azaleella* (Brants)
1965 CEREAL LEAF BEETLE, *Oulema melanopus* (Linnaeus)
1966 LONE STAR TICK, *Amblyomma americanum* (Linnaeus)
1967 ASIATIC OAK WEEVIL, *Cyrtepistomus castaneus* (Roelofs)
1973 GYPSY MOTH, *Lymantria dispar* (Linnaeus)
1974 SOUTHERN GREEN STINKBUG, *Nezara viridula* (Linnaeus)
1976 TWOBANDED JAPANESE WEEVIL, *Callirhopalus bifasciatus* (Roelofs)
1977 IMPORTED CRUCIFER WEEVIL, *Baris lepidii* Germar
1979 HONEYSUCKLE APHID, *Hyadaphis tartaricae* (Aizenberg)
1983 GULF COAST TICK, *Amblyomma maculatum* Koch
1983 A Longhorned beetle, *Neoclytus muricatulus* (Kirby)
1983 A longhorned beetle, *Xylotrechus sagitattus* (Germar)
1984 WHITESPOTTED SAWYER, *Monochamus scutellatus* (Say)

Two Recent Survey Publications

Recreational Fishing in the Kankakee River, Illinois by Robert J. Graham, R. Weldon Larimore, and William F. Dimond is a recent publication in the Illinois Natural History Survey Biological Notes series. This 13-page booklet reports the findings of a 2-year study of the fishermen, fishing effort expended, and fish harvest in the lower Kankakee River and related information.

The researchers found that fishing effort averaged 3,823 man-hours per kilometer per year. Although most of this effort was not expended in pursuit of any particular fish species, the three species caught in greatest numbers were the carp, channel catfish, and shorthead redhorse. The mean annual catch rate for all fish species was 0.13 fish and 56.7 grams of fish per man-hour of fishing effort. The estimated total harvest was 469 fish weighing 217 kilograms per kilometer per year.

A profile of the people fishing the river,

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the methods they used, their reasons for fishing in the Kankakee, and similar information of interest to fishermen, fisheries managers, conservationists, and others is presented in this booklet.

Another recent publication in the Biological Notes series is *Bibliography of Illinois Vegetation* by Paul G. Risser, Chief of the Illinois Natural History Survey. Dr. Risser has gathered together a list of 1,277 publications about the plant life of Illinois and has presented them in bibliographic style to assist researchers, naturalists, and others interested in the vegetation of our state. He has classified also the literature in five indexes.

As Dr. Risser points out in his introduction, "The vegetation of Illinois has been studied for more than 100 years. These studies have produced a rich literature describing the plant communities. . . .

"Collectively, this literature constitut the basis for a number of thoughts an themes about plant ecology — ideas th originated from the work of ecologists wh worked in plant communities in Illinoi . . . The literature on the vegetation c Illinois is impressive in its volume an quality and, as such, represents a soun base upon which to build further studie on the plant communities of the state. A the same time, this bibliography, and th individual indices, indicate that biologist still have enormous opportunities for re warding investigations on the vegetatio of Illinois."

To obtain these or other Survey publi cations, write to the Illinois Natural His tory Survey, 172 Natural Resources Build ing, 607 East Peabody Drive, Champaign Illinois 61820.

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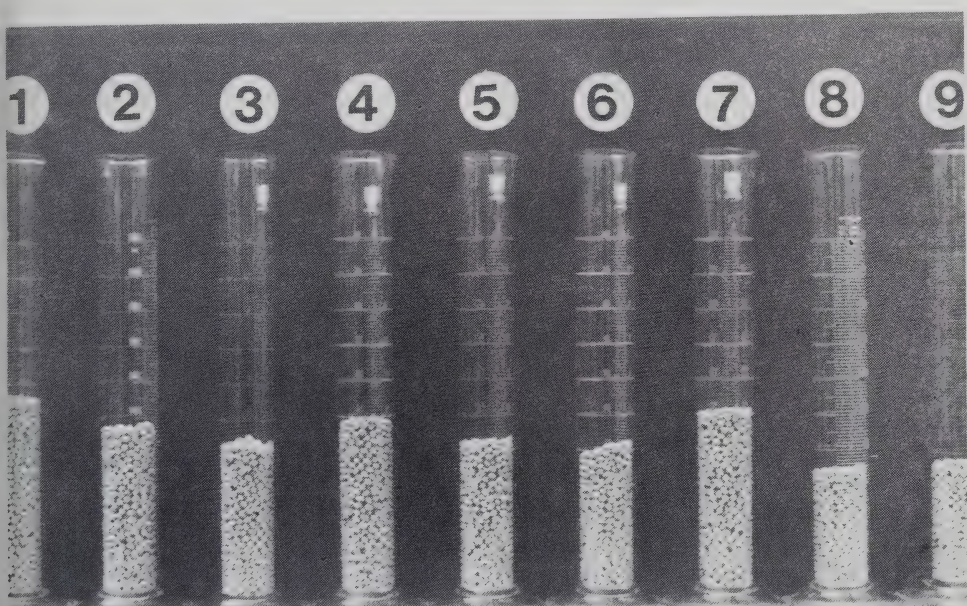
NATURAL HISTORY
SURVEY REPORTS

NOVEMBER 1984. NO. 241

Air Pollution and Illinois Soybean Production

The variety, quantity, and pervasiveness of materials added to the environment concern many persons. These materials include gases, agricultural chemicals, and particulates to the atmosphere, sewage and chemicals to water systems, and solid wastes to the land. Whether they act alone or together, environmental pollutants affect man's food supply, health, and well-being, sometimes adversely. "Smog," or air pollution, is usually identified with large cities, such as Chicago, St. Louis, Los Angeles, or New York. However, scientists are aware of and often disturbed by the apparent increase of air pollutants in non-metropolitan and rural areas whose economic base is frequently agricultural. Indeed, clean air is not the normal environment for plant and animal growth in many locations.

Environmental quality has been a major interest of Illinois Natural History Survey scientists for a long time. The Survey's participation in environmental studies includes investigations of plant-air pollution interactions. Anton G. Endress of the Botany and Plant Pathology Section has con-



Comparisons of soybean yield of plants exposed to ozone alone, sulfur dioxide alone, or mixtures of ozone and sulfur dioxide in greenhouse studies. Cylinder 1 (extreme left) shows the yield from the control plants that received greenhouse air during their development. The addition of ozone alone to greenhouse air reduced soybean yield (compare cylinders 2 and 3 to control), but the addition of sulfur dioxide alone to greenhouse air had no effect on yield (compare cylinders 4 and 7 to control). Mixtures of ozone and sulfur dioxide also reduced soybean yield (compare cylinders 5, 6, 8, and 9 to the control) as much as or more than when ozone only was supplied (Photo by Anton Endress).

structed a chamber system to examine the effects of exposure to air pollutants on the development, growth, yield, and quality of plants.

Endress and a colleague, Claus Grunwald, have recently completed a study of soybean growth and development as it is affected by mixtures of ozone and sulfur dioxide, the two most common gaseous air pollutants in Illinois. Soybeans were examined because Illinois is a leader in soybean production in the United States and several studies have shown that soybeans are sensitive to air quality.

Soybeans (cultivar "Corsoy") were raised in the greenhouse for an entire season. During their growth, the soybeans were exposed to ozone alone at three concentrations for a total of 260 hours, to sulfur dioxide alone at three concentrations for a total of 42 hours, or to mixtures of both ozone and sulfur dioxide. Throughout the study, plants were periodically removed, cut apart, and weights of the various organs determined. At the end of the experiment, the remaining plants were harvested for seed yield.

The periodic plant harvests allowed Endress and Grunwald to evaluate the dynamic response of the soybeans to air pollutant stress. They determined that the air pollution treatments reduced total plant biomass and leaf area. The harvested seeds also showed a response to the presence of air pollutants. Ozone by itself caused reductions of seed weight per plant and weight per seed, while sulfur dioxide alone had no demonstrable effect. However, the mixtures of ozone and sulfur dioxide produced the greatest yield reductions (as much as 38 percent) with fewer pods and seeds per plant and smaller seeds.

Although the results are incomplete, there is apparently no effect of either ozone or sulfur dioxide on the protein content of the seeds.

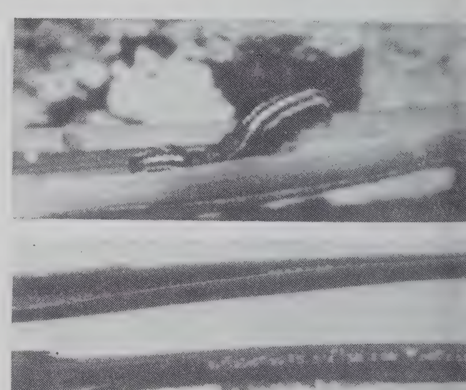
Growth and yield reductions in soybeans caused by air pollutants have been known for some time and have occurred when leaves showed visible markings. The unique findings of these Survey studies are that growth and yield were reduced even though the plants demonstrated no observable symptoms. Furthermore, the scientists w able to isolate the effects of sulfur diox and ozone when the plants were exposed a mixture of these two pollutants.

Stalk Borer Oviposition

The stalk borer, *Papaipema nebris*, c be a serious pest of seedling corn, parti larly of corn planted using conservation reduced tillage practices. Female mo are thought to deposit their eggs on vege tion or plant debris in fence rows, conto strips, grass waterways, or in weedy fie during late summer and early fall. Af the eggs hatch the following spring, larvae begin feeding on grasses but mo to larger plants as they outgrow their ori nal hosts. Corn may serve as this lar plant if planted in or near infested field

To learn which fields might serve as p ferred egg-laying sites for the stalk bor Survey entomologist Eli Levine recen determined the ovipositional preference female moths in cage tests among a vari of weeds and plant debris representative that found in or immediately adjacent corn fields damaged by this pest. In ad tional cage tests, the ovipositional pref ence of female moths among various cov crops typical of those planted under t United States Department of Agricultur payment-in-kind (PIK) crop diversi program was examined.

In the first cage experiment, Levi found that quackgrass and giant foxt were highly preferred by ovipositing mot



Stalk borer eggs deposited on quackgrass. Not how most of the eggs are laid between curled s tions of leaf (Photo by Eli Levine).

while dead foxtail stems, corn stalk debris, and giant ragweed were less preferred. In the second cage experiment using PIK cover crops, orchardgrass and dead winter wheat were among the most highly preferred cover crops tested, while red clover and alfalfa were among the least attractive. The results of Levine's study suggest that female moths prefer to lay their eggs on plants in the grass family, particularly species with numerous leaf sheaths and/or folded or rolled leaves.

Wild females probably behave in a similar manner and oviposit on grasses in fence rows, grass waterways, or contour strips. Oviposition may occur in crop fields if grasses are present during the period moths are laying their eggs (late summer and early fall).

Fields containing these preferred plant species should be closely monitored the following spring for stalk borer infestations if these fields are planted to corn using reduced tillage methods. Good grass control within a field is essential in preventing recurring outbreaks of this pest. Corn producers wishing to participate in a study to evaluate the effectiveness of this technique should contact Levine at the Survey.

WILLIAM F. CHILDERS 1922-1984

DR. WILLIAM F. CHILDERS

In January 1953, while still an undergraduate student, William F. Childers was employed by the Illinois Natural History Survey to help in the trapping and tagging of ducks at the Havana Laboratory. Although it was so cold those first few months that Bill frequently had to chop duck traps out of the ice, he slept in the unheated *Anax,* the Survey's river research boat that had been pulled up in dry dock. From the very beginning of his professional career, Bill Childers had a tough intimacy with natural systems.

In June of that year, Bill began working with Weldon Larimore on warmwater streams, beginning a close professional and personal association that lasted throughout Bill's career. During the following 3 years while working with stream fishes, Bill also studied the behavior of black and white crappies with Professor Hurst Shoemaker, which led to the master's degree in 1956. His first professional honor came when a paper that he and Larimore published on intermittent streams was recognized as the best technical paper published in Volume 88 of the *Transactions of the American Fisheries Society.*

In June 1956, Bill left the stream investigations to work with George Bennett on fish populations of ponds and lakes. With Bennett's consistent encouragement, Bill began his study of hybrid sunfishes that led to his Ph.D. degree in 1965 and to a paper that was judged by the Wildlife Society to be the best fisheries paper published in North America in 1967. Studies of fish genetics occupied his interest for the rest of his career.

With his protege, David Philipp, and with Professor Greg Whitt of the University of Illinois, Bill developed a strong progressive program in fish genetics, which earned both national and international recognition. Bill was twice invited to the USSR to lecture and to attend symposia, and just weeks before his death a paper which he published with Philipp and Whitt received recognition as the best paper of

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Volume 112 of the *Transactions of the American Fisheries Society*. Probably no other American fishery biologist has received such honors for three separate scientific investigations

Bill was a craftsman with great skill and imagination. As his work demanded, he designed and constructed various traps and weirs and showed exceptional creativity in solving technical problems in both the field and laboratory. He was always generous in sharing these abilities with his colleagues.

His deep interest in fish and game behavior and habitat, supported by many special skills with rod, gun, and dog, made Bill an enthusiastic and successful sportsman. He made each cast with the concentrated intention of catching a fish, and with each shot he intended to bring down game. His enthusiasm for fishing and hun ing and his high standards for courte among sportsmen made Bill a pleasa companion in the field.

Bill was a superb storyteller, with fa tastic recall of incidents and details of sp cial episodes. He used storytelling not on in communication but also as an art for — an art form in which he excelled.

Bill died September 20, 1984. To th day, he retained his keen scientific intere in finding the right answers and in draw ing the proper conclusion; but his som times severe scientific discipline was alwa tempered by a kind and generous nature, delightful sense of humor, a great love people, and a joyful enthusiasm for wha ever he was doing.

Recent Publications

Duffield, R. M., W. E. LaBerge, and J. W. Wheeler. 1984. Exocrine secretions of be —VI. Aliphatic esters in Dufour's gland secretion of *Svastra obliqua obliqua* (Hy menoptera: Anthophoridae). Comparative Biochemistry and Physiology 78B(1) 47-50.

Graham, R. J., R. Weldon Larimore, and William F. Dimond. 1984. Recreational fish ing in the Kankakee River, Illinois. Illinois Natural History Survey Biological Not No. 120. 14 p.

Page, L. M., and D. L. Swofford. 1984. Morphological correlates of ecological specia ization in darters. Environmental Biology of Fishes 11:139-159.

Page, L. M., and K. S. Cummings. 1984. A portable camera box for photographin small fishes. Environmental Biology of Fishes 11:160.

Perry, L. G., and John A. Tranquilli. 1984. Age and growth of largemouth bass in thermally altered reservior, as determined from otoliths. Journal of Fisheries Man agement 4:321-330.

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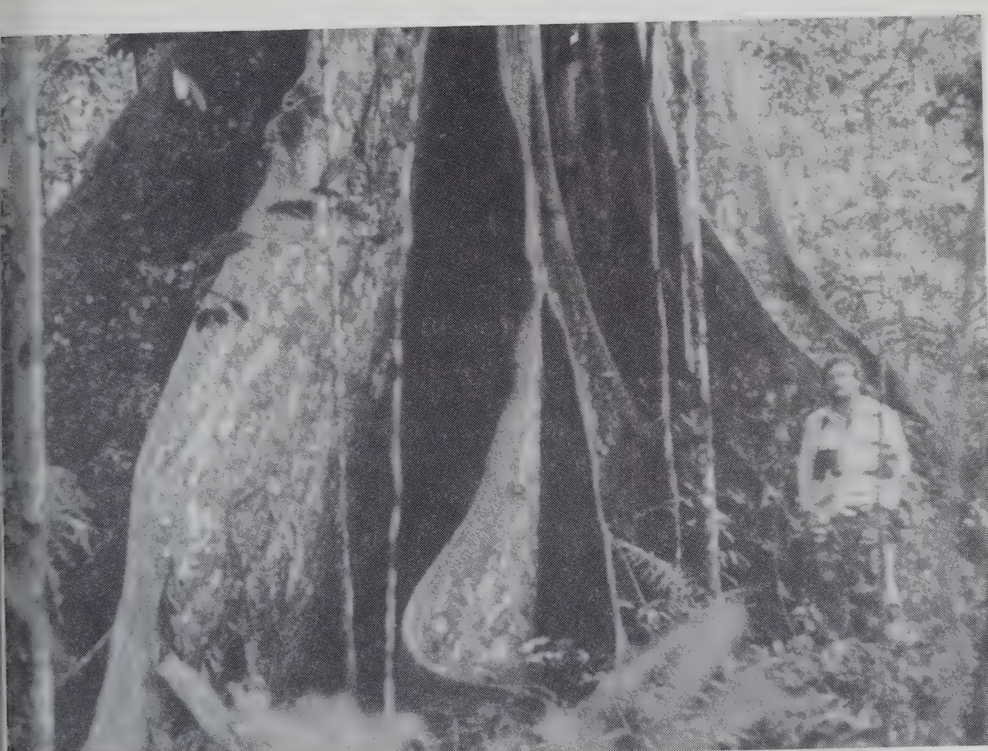
ATURAL HISTORY
SURVEY REPORTS

DECEMBER 1984 NO. 241

ird Communities of Amazonian Forests

Western Amazonia contains the richest, ut least understood, bird communities in ie world, according to Scott Robinson, urvey ornithologist. Several lowland sites ave nearly 550 species in areas of less than 9.5 square miles. These small areas conin far more species than have been reorded in the entire state of Illinois. One of iese sites, the Cocha Cashu Biological Staon in southeastern Peru, has been the site f a long-term study of bird community ynamics since 1973. This site is located in the huge (3.7-million acre) Manu National Park, an area that still contains uncontacted tribes of natives. It takes 5 or 6 days to get to the biological station from Cuzco, the nearest city, 2 days by truck and 3 or 4 days by dugout canoe from the end of the road. The sheer inaccessibility of the site has protected it from logging and systematic hunting. For this reason, the Manu Park has a full complement of species, including many large predators at natural population levels. Large cats, including jaguar, puma, and ocelot, walk the forest



The tree pictured is a *Sloanea*, one of a large genus of tropical timber trees (family Elaeaocarpaceae) having alternate leaves, small petal-less flowers with numerous stamens, and usually very hard wood (Photo by William O. Robinson).

at night. Many large birds that have been hunted to extinction elsewhere are still common and easily found inside the park boundaries. Thirteen species of monkeys, nearly all of which are remarkably tame, abound in the area around the station. In short, the Manu Park provides an excellent opportunity to study pristine communities of birds and mammals. Results of these studies can be used to gain perspectives on the far more disturbed forests of North America, including those in Illinois.

In September and October, Robinson took a leave of absence from the Survey to continue an intensive study of the Manu bird community in collaboration with John Terborgh of Princeton University. This project, funded by the National Science Foundation, involves a large-scale census of the birds found in each of the major habitats of the Manu Park and an investigation of the factors that determine which species occur in each habitat.

Mature forest, which is exceedingly complex in structure, contains the greatest number of species (240 species per 250 acres), whereas the structurally simple successional vegetation along river edges contains the fewest species (85 species per 250 acres). However, both habitats contain 5 to 10 times more species than do habitats of comparable vegetation structure in Illinois. Tropical birds, however, are rarer on the average than birds of temperate forests. Roughly 190 of the 240 species found in mature forest have population densities of fewer than 5 pairs per 250 acres. Many small insectivorous birds have territories of 12-49 acres, which is 5 to 10 times larger than those of comparably sized birds in temperate forests. Apparently, the tremendous increase in species richness of tropical forests comes at the expense of decreased population densities of each species.

Neotropical migrants, many of which breed in or pass through Illinois, are largely restricted to river edge and successional habitats on their winter grounds in southeastern Peru. Shorebirds, including 13 species that migrate through the Midwest, occur on the beaches that are exposed when the river level drops during the dry season (June to November). Such familiar

Illinois species as Eastern Pewee, East
Kingbird, and Swainson's Thrush are m
abundant in floodplain forests domina
by mahogany, figs, and trees of the lau
family. Unfortunately, these river-ed
forests are the first to be logged and co
verted to agriculture following hum
settlement. Very few North Americ
species winter in mature upland fore
which covers most of the Amazon basin.

Robinson and Terborgh have found e
dence that interspecific aggression a
may play a key role in determining wh
species occur in each habitat. A comm
pattern is for closely related species
occupy different habitats. In the Ma
area, often one species occupies ea
successional vegetation and another fr
the same genus occupies mature forest.
these pairs of species, one is usually do
inant over the other. The dominant spec
attacks when it hears the song of the su
ordinate. The subordinate species, in tu
usually retreats when it hears the song
the dominant. Apparently the domina
species, generally the larger of the tw
occupies the preferred habitat and forc
the smaller one into marginal habitat.
date, this relationship has been found in
of 14 genera tested. These results sugg
that interspecific competition may be wid
spread and important in determining ha
itat selection in Amazonian birds.

Nest predation also plays a key role
determining habitat selection in ma
Amazonian birds. Many arboreal mar
mals (including most monkeys), snak
hawks, and even toucans are invetera
predators of the eggs and young of bir
Though few species have been studied
detail, predation rates for some speci
probably approach 90 percent of all nes
To escape predation, birds must either hi
their nests in tree holes or dense vi
tangles or nest in areas where monke
cannot reach them. Isolated trees, such
those on islands, are often covered wi
nests of many species, some of which a
colonial. The availability of such safe ne
sites may play an important role in limiti
the populations of many tropical species.

Such studies of tropical bird commu
nities can provide valuable insights in

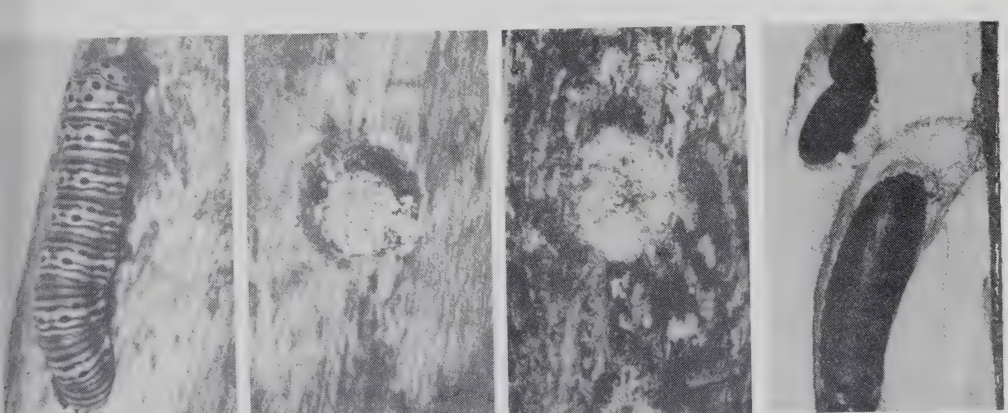
hat factors might also be structuring mperate communities. Competitive inter-ctions, which appear to be important in a reat many tropical genera may also be nportant in the temperate zone, where nany closely related species occupy differ-nt habitats. Similarly, nest predation may e far more important in temperate bird ommunities than is generally recognized. erhaps the major advantage of working n the temperate zone is that many species re common and therefore relatively easy study. Therefore, tropical forests provide ne opportunity to study ecological inter-ctions between many species, while tem-erate habitats provide an opportunity to tudy fewer species in much greater detail.

nug As a Bug in a. . . . .

Pearly wood nymph caterpillars (*Eudryas nio*) begin abandoning the leaves of their ost plants, evening primrose (*Oenothera*), villow herb (*Epilobium*), and grape *Vitis*), in late September and early Octo-er in search of suitable pupating and over-vintering sites. Many of *Eudryas unio*'s ,000 moth relatives in North America un-btrusively construct pupation chambers n the duff, or below the soil surface. In contrast, *E. unio* prefer to pupate in soft vood or the stems of large, erect herbs and xcavate their chambers with remarkable ersistence. One Madison County resident near Edwardsville observed this activity in September 1983, reporting to the Survey hat "thousands" of caterpillars (identified as *E. unio* by Survey entomologist G. L. Godfrey) were "eating" recently purchased lumber that had been stacked near his home.

Caterpillars and pupae of *E. unio* were found in dead stems of the soldier rose-mallow (*Hibiscus militaris*) in Cleveland, Ohio, in 1868, according to the late C. V. Riley, internationally known entomologist. On October 13, 1983, Godfrey and his Survey colleague, D. J. Voegtlin, observed a similar situation in clumps of soldier rose-mallow in Fayette County near Carlyle Lake, although living stems also were in-volved. By splitting the stems, they found eight pupal chambers, each within 25 cm of the stem base. Two chambers held *E. unio* which had not yet pupated, and the caterpillars which had been exposed began to construct new chambers on intact stem segments.

One caterpillar spent 11 hours and the other 12 in completing their new chambers, including the addition of "window dress-ing." Excavation commences with the cater-pillar, head downward on the stem, biting a hole 4-5 mm wide (just large enough for passage of the caterpillar's head) in the stem and discarding the removed pieces of stem tissue onto the ground. This sounds simple. However, bear in mind that the caterpillar keeps biting, inwardly and obliquely downward for nearly its full body length, while intermittently ejecting stem material packed between its mandibles from the chamber without retreating from



Eudryas unio pupal chamber (left to right): a larva cutting the entrance hole (1 hour), wood chips being attached to the clear silk plug (10 hours later), a camouflaged plug (separate specimen), a split stem with the pupa in the chamber (the top chamber contains the puparia of a parasitic tachinid fly) (Photos by G. L. Godfrey).

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it. The head and part of the body fill the chamber during the biting process, but the caterpillar, with its flexible exoskeleton, has enough agility to loop itself sideways, bring its mandibles to the chamber's entrance, and shove out the scrapings with its hypopharynx ("tongue").

After approximately 9 hours of excavating, the caterpillar turns end for end. With its head now directed toward the entrance, the caterpillar spins a silk plug over the hole. The strands of silk coalesce and by themselves would form a transparent wi dow, but during the 2- to 3-hour spinnir process, small particles of stem are take from the top of the chamber and attache to the inner surface of the plug to effe tively conceal the entrance. Under natur conditions the caterpillar pupates withi a week, and the resultant pupa is qui protected by its chamber through autum winter, and spring. The moth of *E. un* escapes from the pupal case and brea through the silk plug to emerge the follov ing summer.

Recent Publications

Risser, P. G. 1984. Bibliography of Illinois Vegetation. Illinois Natural History Surve Biological Notes No. 121. 51 p.

Voegtlin, D. 1984. Notes on *Hyadapis foeniculi* and redescription of *Hyadaphis tataric* (Homoptera: Aphididae). Great Lakes Entomologist 17(2):55-67.

Webb, D. W. 1984. A revision of the Nearctic species of the family Solvidae (Insect Diptera). American Entomological Society Transactions 110:245-293.

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NATURAL HISTORY SURVEY REPORTS

JANUARY [illegible]

he Biogeochemistry of North merican Ungulates

In a study published in 1976, Harold C. Ianson of the Illinois Natural History urvey and Robert L. Jones, a soil mineralgist at the University of Illinois Departnent of Agronomy, reported on the relaionships between minerals and soils and heir absorption by plants, their consumpion and absorption by geese, and the nineral levels found in feather keratin. Keratin essentially functions as a metabolic vastebasket for excess minerals. Insights nto the progression of minerals through his segment of the ecosystem enabled these nvestigators to determine the birthplaces of wild geese. These findings have been hown to have immense practical applicaion to the management of migratory birds, particularly waterfowl.

A spin-off of this study and of an evaluation of the role of sulfur in ecosystems was the realization that, despite many decades of study by big game specialists, the biogeochemical aspects of mineral licks of big game (ungulates) were poorly understood. Yet the dependence of ungulates, worldwide, on mineral licks for survival has probably been known since the time of early man. The failure in recent decades to arrive at a common denominator, or denominators, involved in mineral lick use was that each study had been confined to a small area. It became apparent that the phenomena would be subject to deciphering only if the use of mineral licks was studied comparatively against the whole spectrum of geologies on which the animals live.

To remedy this gap in the knowledge of ecosystems, Jones and Hanson solicited a continent-wide collection of earth materials from mineral licks to learn the chemical basis of the dependence of animals on earth supplements in their diets. The result of this endeavor is a book just published by Iowa State University Press — *Mineral Licks, Geophagy, and Biogeochemistry of North American Ungulates.*

Dall sheep at mineral lick somewhere in Alaska (Photo by Wayne Heimer).

The authors found that the primary reason that ungulates visit mineral licks is to avoid grass tetany — a convulsive condition that can lead to death resulting from the consumption of spring forages inordinately high in potassium and low in magnesium. As the plant matures or growth proceeds, there is a delayed or latent absorption of magnesium by the plant. This sequence of events has been shown to be

exhibited in the hair of moose. These relationships have overriding significance, as both magnesium and calcium are required for the normal transmission of nerve impulses and muscular responses.

Licks high in sodium or magnesium and/or calcium solve the seasonal mineral imbalance for plant consumers — sodium by its reciprocal effect in reducing potassium levels and magnesium by compensating for losses of this latter mineral caused by an increase of the hormone aldosterone from the adrenal cortex. Concomitantly, increased sodium intake probably aids in more efficient absorption of magnesium — thus having a dual effect in correcting mineral imbalances resulting from high potassium intake.

The results of mineral lick analyses and the line of reasoning developed in this study have been applied to the understanding of two age-old riddles — the 4-year cycles in rodents, particularly the microtines (meadow mice and lemmings), and the 10- to 11-year cycle of abundance in snowshoe hares. The die-off of lemmings has been associated in spring with convulsive conditions — both in Norway and Alaska. In snowshoe hares, the die-off at population peaks has been called a response to "shock disease" or hypoglycemia — basically a low blood sugar condition. But magnesium is a required co-factor for 8 of the 13 enzymatic steps in the glycolysis, or the metabolism, of blood sugars. Readily drawn upon magnesium reserves in animals have very narrow limits. Thus, this factor, coupled with possible cyclic lows of magnesium in woody plant foods and in geologic substrates and soils low in magnesium, sets the stage for die-offs precipitated by mineral imbalances.

Insect Resistance in Soybean Pest Management

An insect-resistant variety of a crop plant is one that possesses some biochemical or morphological trait which allows it to avoid, tolerate, or recover from insect injury. If possession of these traits prevents a particular insect species from reaching damaging population levels, the use of such varieties becomes a very powerful pest management

Erect hairs along stems and leaves of most commerc
soybean varieties interfere with potato leafhopp
feeding (Photo by Y. I. Lee).

tool. For example, the erect hairs alor
the stems and leaves of most soybea
varieties have virtually eliminated tl
potato leafhopper (a tiny sucking insect
as a potentially serious pest of this cro
This simple morphological trait of mo
commercially grown soybean varieties pr
sents an effective barrier to feeding ar
egg laying by this highly mobile, abundar
insect pest.

Since 1970, entomologists, plant physio
ogists, and biochemists at the Illino
Natural History Survey and plant breede
and geneticists at the United States D
partment of Agriculture Soybean Labora
tory on the University of Illinois campu
have teamed their efforts to better unde
stand the insect host-selection process an
the physiology of resistance within th
soybean crop. This program in host-plan
resistance has two main components: (1
breeding soybean plants for improved re
sistance to defoliators and (2) studyin
the mechanisms of resistance.

Within the breeding portion of the pro
gram, Survey entomologists routinely scree
as many plant introductions, breeding line
and varieties from the germ plasm collec
tion as possible. During 1984 alone, ove
370 breeding lines were evaluated in th
field and in laboratory choice tests fo
resistance to insect feeding. Through th
course of this research, thousands of soy
bean lines have been screened, and num
erous varieties have shown measurabl

evels of resistance to one or more insect pests. A primary goal of the Illinois breeding program has been to transfer desirable resistance factors into agronomically acceptable varieties. Using plant introductions numbered 171451 and 229358 as sources of resistance (previously identified in South Carolina as highly resistant to the Mexican bean beetle), five promising soybean lines have been developed and released for public use in additional breeding programs.

Efforts to better understand the exact mechanisms of the resistance phenomenon in the soybean crop must deal not only with the morphological and biochemical differences between resistant and susceptible varieties, but also with the way in which the insect perceives them. In-depth plant-chemical profiles of resistant and susceptible lines are being compiled in an attempt to detect subtle differences which may explain the insect response to a given food plant. Additionally, detailed morphological and electrophysiological studies of insect sensory structures are under way, and these may help to explain exactly where and how an insect makes the decision to accept or reject a soybean line as a suitable host.

Unlike the example of leaf hairiness and the potato leafhopper, the causes of most insect resistance in crop plants are likely to be complex and very seldom due to a single trait or chemical. Progress toward the development of agronomically acceptable, insect-resistant soybean cultivars has been painstakingly slow. However, given the complexity of the host-plant selection process and the difficult genetic manipulations required in the breeding program, this time frame for the development and release of insect-resistant soybean varieties is not abnormal.

Nevertheless, host-plant resistance has tremendous potential for future use in successful integrated pest management programs. Resistant varieties are highly compatible with existing management strategies, should lower production costs, and should reduce or even eliminate the need for insecticide applications, thereby improving the quality of our environment. Continued emphasis on the development and understanding of insect resistance in soybeans by this multidisciplinary team should result in insect-resistant varieties becoming a major component of pest management systems for Illinois soybean producers.

Survival Rates in Squirrels

Gray and fox squirrels are among the most popular small game animals in Illinois, with annual harvests exceeding 1 million. Unfortunately, information from unexploited fox squirrel populations, which could be used to aid in the understanding of fox squirrel population fluctuations and the establishment of harvest regulations, has not been available.

Wildlife ecologists Charles Nixon, Lonnie Hansen, and Stephen Havera studied an unhunted fox squirrel population for 7 years to answer questions about the demography of squirrels. These answers will be pertinent to management practices. One of the most important questions investigated involved survival rates and factors affecting survival rates in natural populations of fox squirrels.

Longevity of male and female squirrels

Young fox squirrels nesting in wood duck box (Photo by W. E. Clark).

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was found to be similar but squirrels 1 year and older when first captured lived on the study area much longer than those less than 1 year old when first captured. These differences likely reflected not only higher mortality rates of young squirrels, but also a greater tendency of young to scatter from the study area. Surprisingly, fox squirrel survival was not correlated with production of tree seeds, as has been found by researchers studying gray squirrels. This lack of correlation may be attributed to the abundance of tree seeds during the 7-year study, the varied diet of the fox squirrel compared with that of the gray squirrel, and the tendency of fox squirrels to use agricultural crops. Severity of winter weather, as indicated by snowfall and temperature deviations from normal, also did not appear to affect recapture rates.

Recapture rates of subadult and adult immigrant squirrels were negatively cor related with densities of adult female Survival of resident squirrels was n affected by adult densities. These resul suggest that social conditions initiated b the adult female may limit the number o new squirrels recruited into the populatio Maximum densities of fox squirrels withi a forest, therefore, could be limited i this way.

These results have important manage ment implications because they suggest tha attempts to increase squirrel densities arti ficially, for example, by releases, woul likely fail if a resident squirrel populatio were present. Detailed experimental studie of fox squirrels are currently being per formed to substantiate the role of adults i density regulation and to evaluate th effects of exploitation on fox squirre demography.

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GY AND NATURAL

NATURAL HISTORY SURVEY REPORTS

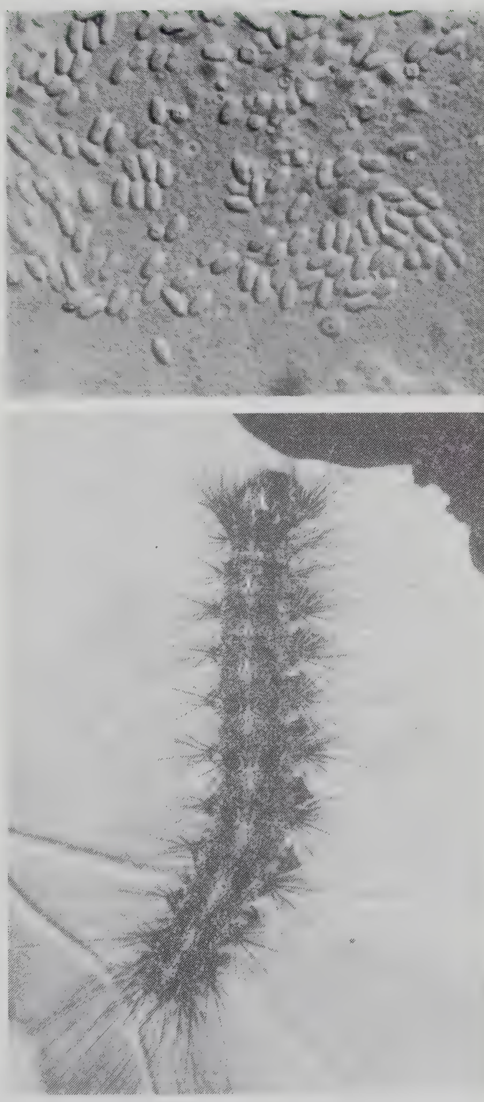
FEBRUARY 1985, NO. 244

;cientists Seek Biological :ontrol of Gypsy Moth

As part of a cooperative agreement with he U.S. Forest Service, Survey entomol-gists Joseph Maddox and Michael Jef-ords will travel to Europe this spring to ollect microscopic, single-celled organisms alled microsporidia from gypsy moth pop-.lations. These pathogens, disease-produc-ng organisms, will be tested, both in the aboratory and in a greenhouse model for-st ecosystem, for their potential as bio-ogical control agents of the gypsy moth nd for their environmental safety. Mad-lox and Jeffords hope to find one or more romising species to introduce into North American gypsy moth populations as per-nanent mortality factors. If these efforts rove successful, it will be the first time hat a classical biological control program nvolving a pathogen will have been con-lucted against the gypsy moth.

Many insects that have attained pest tatus in the United States, including the ypsy moth and European corn borer, are ot native species but were introduced rom other countries. When an imported nsect encounters a new environment with uitable weather conditions and abundant ood, it often undergoes an explosive pop-lation increase because it has been intro-uced *without* its natural enemies — or-anisms that use the insect as a food esource. Natural enemies, including preda-ors, parasites, and pathogens, are ex-remely important in keeping insect popu-ations in check.

Biological control is the planned reloca-on of natural enemies from one place to nother. The objective of classical bio-ogical control is to find the most effective



Microsporidian pathogens collected in Europe will be studied for their potential as biological control agents of the gypsy moth in North America. **Top:** Spores of a microsporidium in the genus *Nosema* — actual length 5 microns (Photo by J. V. Maddox). **Bottom:** Mature larva of the gypsy moth, *Lymantria dispar* — actual length about 2 inches (Photo by J. E. Appleby).

natural enemy species and to colonize them in the new environment of the pest insect. The first successful biological control in the United States took place in 1888 when the predaceous vedalia beetle was imported from Australia to control the devastating cottony cushion scale. The fledgling citrus industry in southern California was saved, which generated a great deal of enthusiasm for this control strategy. Many successful introductions of natural enemies followed.

The United States Department of Agriculture first became involved in the biological control of pest insects in 1905 by importing natural enemies of the gypsy moth. The gypsy moth was brought from Europe to Massachusetts in 1869 by Leopold Trouvelot, who had planned to breed it with the silkworm to produce a better silk-making caterpillar. Several gypsy moths escaped during the course of his experiments, and within a few years populations were high enough to cause noticeable defoliation of trees in the area. Since its inception, the U.S.D.A. gypsy moth natural enemy introduction program has resulted in the establishment of one predator species and ten species of parasites imported from Europe and Asia. Although the combined mortality inflicted by these imported species can be significant, the gypsy moth continues to reach outbreak levels, especially in newly invaded parts of its range. In 1981, one of the worst gypsy moth outbreaks to date occurred: 13 million acres of trees were defoliated and damage was $764 million nationwide.

Researchers are beginning to find that pathogens are often the most important mortality factors affecting forest insect populations. While most classical biological control work has involved introductions of parasites and predators, success has been achieved in Canada by using imported viruses to control forest insect pests. In the United States only one pathogen, a nucleopolyhedrosis virus (NPV), causes significant gypsy moth mortality. Gypsy moths in Europe, however, are infected by a number of other pathogens in addition to the NPV, including microsporidia. High levels of microsporidian infection have been implicated in the collapse of gypsy moth populations, and if Maddox and Jefford find the right ones, control of the gyps moth may improve greatly.

Supplement to *Aquatic Oligochaeta of the World* is Published

Oligochaete! Thou taxonomic pain!
My mouth and mind and memory affirm
'Twould be much less a stress upon the brain
To designate you merely as a worm.
But then again, perhaps it is untrue
To brand you as too simple for your name.
For possibly, the tests we put you through
Just don't quite fit your undulating frame.
Psychologists are on the highest ground
When studying the ways of mice and men.
But with invertebrates they're often found
Quite ignorant of how they should begin.
The object of my study is to try
To help both man and worm see eye to eye.

— D.N. Howell (1974)

Earthworms are familiar enough to any one who has worked with soil or gone fish ing. More than 80 percent are close rela tives of the common garden earthworm Several families of worms are entirel aquatic, while other families which ar primarily terrestrial have one or mor genera inhabiting aquatic or semiaquati habitats. In December 1984, Dr. Ralph O Brinkhurst of the Institute of Ocean Sci ences in Sidney, British Columbia, and Mark J. Wetzel of the Section of Faunistic Surveys and Insect Identification, pub lished a paper entitled *Aquatic Oligochaeta of the World: Supplement. A Catalogue o New Freshwater Species, Descriptions, and Revisions.*

This contribution provides an annotated list of freshwater oligochaete genera and species described or revised since the global review of the literature on this subject by the senior author and B. G. M. Jamieson

1971. The intent of the authors was not provide a formal taxonomic revision ised on the examination of old and new aterial, but rather to organize and present recent published information so that ch revisions by subsequent authors might completed more efficiently. This comlation should be particularly useful to ithors wishing to publish species descripons, revise copies of regional keys, or cognize synonyms employed in the wider, ontaxonomic literature. Discussions of iajor diagnostic characters of new taxa, ossible synonyms suggested by the literaire, and transfers of species between enera which result in several new cominations are presented.

The most significant change in oligonaeta systematics since 1971 has been the ecognition of intraspecific variation and nvironmental modification of setae, or airs, resulting in the synonymization of ome species. The authors report on several esearch programs which question the prior eavy reliance on setal form for generic ecisions, even in the presence of other disnguishing characteristics. Increasingly rened research being conducted on oligohaete systematics has suggested that the ssue is really one of intraspecific variation i any character. Other research programs iave demonstrated that some setal forms eflect a degree of development rather than he presence or absence of certain charcters, as described in most species definiions. The authors suggest that such fine lifferences between species within certain amilies of worms, established by the typoogical method, may have little practical alue for ecologists; the resolution of this ssue depends on an increase in the amounts of field work on these families, which has ust begun.

Lead Poisoning in Illinois Waterfowl

Ducks, geese, and other birds become xposed to lead poisoning when they ingest lead shotgun pellets that have been leposited in waterfowl habitat as a result of sport hunting. The pellets are retained n the gizzard, where the lead is gradually lissolved and then absorbed by blood and ubsequently by other body tissues. In ad-

Dr. Frank Bellrose, nationally known wildlife specialist who recently retired from the Survey's Havana field station, retrieving dead ducks that ingested lead shot at Rice Lake, near Banner, Illinois.

dition to contaminating the bird's blood, liver, and kidneys, lead also enters the brain. Such contaminated birds often die. In fact, in his definitive study of lead poisoning, Survey researcher Frank C. Bellrose estimated in 1959 that 2-3 percent of the entire North American waterfowl population succumb to this disease annually. With today's populations, this means a loss of 1.6-2.4 million birds each year.

Illinois Department of Conservation biologist William L. Anderson and Survey researcher Stephen P. Havera recently investigated the extent and severity of lead poisoning among waterfowl in Illinois. In a sample of 13,246 gizzards from mallards harvested on 55 areas from 1979 through 1983, 5.9 percent contained one or more ingested pellets. Ingested pellets were found in gizzards from virtually all areas, revealing that lead poisoning occurs throughout the state. Incidences of ingested pellets in mallard gizzards exceeding 10 percent occurred in several areas in some years, and the astounding rate of 20 percent, or one out of every five gizzards, was evident on occasion. For lesser scaup, more popularly called "bluebills," the incidence of ingested pellets in 753 gizzards was 3.2 percent. In a sample of 526 Canada geese, the incidence was 4.2 percent.

When it is recognized that these ingestion rates represent merely "still images" of a dynamic process in which lead pellets are continuously being ingested and dis-

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solved (in about 3 weeks), it is evident that 20-30 percent of Illinois' waterfowl population is contaminated with lead each year. Incorporate into this calculation the fact that several million ducks and geese migrate through or winter in Illinois annually, and the number of individual waterfowl that contract lead poisoning in our state becomes excessive.

Anderson and Havera extended their investigations of lead poisoning by collecting blood samples of 2,265 waterfowl captured on seven areas during the fall and winter periods of 1980-1981 through 1982-1983. These blood samples were analyzed for concentrations of lead and protoporphyrin. Protoporphyrin is a precursor to hemoglobin, and it increases as a response to lead poisoning in ducks and geese. The rates of lead poisoning indicated by elevated protoporphyrin in blood were equal to or greater than those suggested by ingested pellets in gizzards. Moreover, lead poisoning as revealed by elevated lead in blood was about twice as great as the rates indicated by elevated protoporphyrin levels and ingested pellets. It was evident that lead in blood was the most sensitive technique for detecting lead poisoning in waterfowl, protoporphyrin in blood w intermediate, and ingested pellets in gi zards was the least sensitive. Anderson an Havera concluded that the incidence ingested pellets in gizzards provided co servative estimates of the severity of lea poisoning in Illinois' wild waterfowl popu lations. Thus, lead poisoning of waterfow in Illinois is probably more serious tha originally predicted.

Research has shown that the ingestion a single lead pellet by a duck always r sults in lead contaminating the blood, live kidneys, and brain. The very least cons quence of waterfowl ingesting lead is th inhibition of enzyme activity in these vit body tissues, and, at least in the brai cellular damage occurs. The brain damag is irreversible, and without question plac the bird at a disadvantage in attemptin to survive, migrate, and reproduce in th wild. The other possibility is death as th result of acute lead poisoning. The loss thousands of waterfowl throughout th United States to lead poisoning each yea can be eliminated by the conversion to non toxic steel shot for use in the sport huntin of ducks and geese.

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NATURAL HISTORY
SURVEY REPORTS

MARCH 1985, NO. 245

Frank Bellrose Receives Aldo Leopold Medal

FRANK BELLROSE

Frank Bellrose, former wildlife specialist at the Survey, was presented the Aldo Leopold Memorial Medal for his distinguished service to wildlife conservation at the 50th Anniversary meeting of The Wildlife Society in Washington, D.C. recently. The award is the ultimate recognition of a wildlife professional and Bellrose is the first Illinoisan to receive it.

The dedication and deep convictions of this scientist have led to a better understanding of wetland resources. He has long been concerned with the wildlife trends and problems along the Illinois and Mississippi flyways. The first scientist to report the poisoning of countless waterfowl by lead shot, he is closely associated with excellence in waterfowl research and management and is widely regarded as "Mr. Waterfowl."

Over 90 publications are credited to his work and consist of a wide variety of topics ranging from waterfowl food plants, to muskrats, to waterfowl migration corridors. One of his most notable contributions is associated with the rewriting and revision of the *Ducks, Geese, and Swans of North America*. This book has been recognized as one of the most complete waterfowl references in print.

He has received numerous honors and awards, including The Wildlife Society Publication Award, the Oak Leaf Award from the Nature Conservancy, American Motors Conservation Award, and the National Wildlife Federation Conservation Award. He is a Fellow of the American Ornithologists' Union, an honorary life member of The Wildlife Society, and recipient of an Honorary Doctor of Science degree from Western Illinois University.

The 1985 honoree was born in Ottawa in 1916, and completed his academic training in Zoology at the University of Illinois. His wildlife career began with the Illinois Natural History Survey in 1938 as an Assistant Game Technician. He progressed to Assistant Game Specialist in 1945; to Wildlife Specialist in 1955; and to Principal Scientist with the Survey in 1981. Since 1963, he has been an Adjunct Professor and Research Associate at Western Illinois University.

Bellrose retired from the Survey in 1983, but he continues to work almost daily at the Havana Laboratory or in the field.

Sapsuckers Damage Trees

Sapsucker damage is caused by a bird known as the yellow-bellied sapsucker, a member of the woodpecker family. The damage caused by the sapsucker is primarily done in early spring when the bird migrates back from its winter environment. Small, closely spaced holes formed in regular rows around the trunk and branches can be found on pine, birch, maple, linden, and other tree species that "bleed" freely from bark wounds. The "drilled" holes made by the sapsucker extend into the wood and usually completely encircle the stem and branches, and are the result of the natural feeding habit of the bird. The bird is one of the smaller woodpeckers, having black and white plumage, a wide white stripe on the wings, a red patch on the forehead, and a yellowish breast.

Unlike most members of the woodpecker family, sapsuckers rarely drill into the bark to search for insects, but do drill holes in the bark of healthy trees to obtain tree sap on which they feed as it seeps from these bark wounds. It is believed that half of the food material sapsuckers consume, at least in early spring, is composed of sap and of the insects that are attracted to tree sap. Some of their other foods are small fruits and insects they catch on the bark. Hummingbirds also visit rows of sapsucker holes to feed on the sap and insects.

Because several rings of holes are frequently made, and because trees may be injured several years in a row, the bark can be riddled with wounds that cause severe reduction of the normal transport of sugars down to the root system. Also, the outer wood is damaged and water and nutrient transport to the crown is greatly reduced. When several bands of holes extend around the branch or trunk, the top of the tree may die. Sometimes on smaller trees a bulge will develop above the ring of holes indicating a backup of sugar transport through the inner bark.

In areas of high sapsucker migration, many Scotch pine and sugar maple trees will exhibit injury made over a period of several years. Towns in agricultural areas, such as east central Illinois, tend to attract many sapsuckers because there are so few

The branch sections pictured were cut from Sco pines that were fed on heavily by sapsuckers. Af one to two years, sapsucker wounds will develop square or rectangular holes in the bark as a res of further tree growth.

trees in the region. In addition, many the trees that have been planted as orn mental shade trees are among the favorit of the sapsucker. Frequently, one tree w be singled out for heavy feeding. Becau the birds are shy creatures, they are easi disturbed by humans, are observed infr quently, and are seldom seen or hea when they drill holes in the trees on whi they feed.

Sticky, bird-repellent materials appli to the trunk have not been successful repelling sapsuckers, and they are impra tical to apply to large areas of a tree trun Strips of shiny aluminum foil that w flutter in the wind and are attached string to a few branches may help frighten the birds away. No other pr cedures are known that have been succes ful repellents. Injured trees will be help in recovering from sapsucker injury if th are fertilized in the spring or early sur mer, and watered during the dry perio of the summer.

Survey Investigates Fruit Crop Pest

The plum curculio, *Conotrachelus nen phar* (Herbst), feeds on many fruit cro

ıst of the Rocky Mountains, including ɔple, apricot, blueberry, cherry, nectarine, ɛach, and plum. Adults feed on green ·uit in the spring, and sometimes on pening fruit in the fall. Females make ·escent-shaped incisions on the fruit, layıg a single egg in each incision. The deɛloping larva feeds inside the fruit, and ıay cause premature fruit drop.

Less is known about the plum curculio ıan any other key pest of stone or pome ·uit. Scientists have been unable to preict exactly when plum curculio will first ppear on fruit crops in the spring. As a esult, growers are forced to apply several ısecticide treatments to ensure that at ɛast one application will be on time to ırevent plum curculio damage.

Milt McGiffen, an Assistant Supportive ɜcientist in Economic Entomology, found hat insecticide usage could be greatly reluced if sprays were precisely timed. While working with John Meyer at North Carolina State University, McGiffen examined the effect of environmental factors on overwintering behavior and spring migration in plum curculio, hoping to find a key to the accurate prediction of the spring appearance of *C. nenuphar* on fruit crops. He concluded that the return of plum curculio to their host plants is the result of two events in the insect's life cycle, diapause termination and postdiapause migration.

Diapause is a state of suppressed development similar to hibernation. Respiration rate, characteristically low during diapause, may be used as an assay for the physiological changes associated with overwintering. With the aid of a gas chromatographic technique developed by a fellow graduate student, Jack Boyne, McGiffen used the respiration rate to determine when diapause ends in plum curculio. He

(Upper left) Plum curculio rests on the fuzzy surface of a peach. (Lower right) Adult curculio make crescent-shaped incisions on fruit. The developing larvae feed inside the fruit and may cause premature fruit drop.

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found that diapause termination (the physiological processes involved in completing diapause) is completed before winter ends, and thus does not determine when spring migration is initiated. Low temperatures act to suppress activity and conserve energy during the transition from diapause to reproduction, a life stage called postdiapause development.

Plum curculio is vulnerable to starvation if sustained periods of warm temperatures occur during postdiapause development. However, most overwintering plum curculio do not initiate migration to food plants until the temperature reaches 60°F (to warm flight muscles) and relative humidity exceeds 50 percent (plum curculio are sensitive to desiccation or drying out). Further, deaths due to the insect disease, *Beuvaria bassiana* (Balsamo) Vuillemin, increase rapidly as temperature rises.

The impact of these factors on plum curculio populations may be severe during certain situations. If spring weather warm and dry or fruiting of host plan is not synchronized with migration, plu curculio populations may suffer high mo tality rates. From an evolutionary stan point, the plum curculio's dependence c temperature and humidity as signals initiate migration are understandabl spring is usually humid, and host fru availability is dependent upon temper ture.

Because of these findings, it was co cluded that the timing of plum curcul migration from overwintering sites to hc plants is critical in predicting when tl pest first appears on fruit crops. A simp model of the relationship between plu curculio flight initiation and ambient ter perature and humidity was developed. R searchers hope the model's predictions w allow more precise timing of insecticid applications, and thus lead to better co trol practices for this serious pest.

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NATURAL HISTORY

REPORTS

APRIL 1985, NO. 246

Endangered Illinois Fishes

A large number of fishes have disappeared from Illinois within historical time, and several more are on the verge of extinction. Already gone from Illinois are the Ohio lamprey, blackfin cisco, longjaw cisco, rosefin shiner, greater redhorse, gilt darter, stargazing darter, crystal darter, and native populations of the muskellunge. On the verge of extinction are several other fishes, the more critical of which are the lake sturgeon, alligator gar, cypress minnow, bigeye chub, bluehead shiner, pugnose shiner, blacknose shiner, northern madtom, and harlequin darter.

For some species nearing extinction in Illinois, the problem seems to be an inability to adjust to pervasive aspects of environmental degradation (e.g., stream siltation) over a large area of the state, and it may not be possible to prevent the loss of these species. An example is the bigeye chub, which once ranged over much of eastern and southern Illinois but now is found in only a few small streams. For other species, the protection of critical habitat could save the Illinois populations. Among the most endangered fishes in Illinois are six species which appear to fall into the latter category: the cypress minnow, pugnose shiner, bluehead shiner, northern madtom, bluebreast darter, and harlequin darter. Each is confined to a small area of Illinois and appears to be endangered because its population is small and vulnerable even to minor modifications of its habitat.

A study designed to locate the largest Illinois populations of three endangered fishes, the pugnose shiner, bluehead shiner, and harlequin darter, and to identify characteristics of the habitat most critical to their survival, was initiated by Survey scientists L. M. Page and K. S. Cummings. These three fishes were selected because they are considered extremely endangered in Illinois, and protective measures must be taken quickly if Illinois populations are to survive. Fortunately, all occur in areas and habitats amenable to protection. With partial funding by the Illinois Department of Conservation, field work began in July 1984 and should be completed by the fall of 1985.

The pugnose shiner has been referred to as one of the rarest minnows in North America, and one which is undergoing an alarming decline throughout its range. Its decline seems to be related to increased turbidity and the concomitant loss of aquatic vegetation. It has disappeared from the state of Ohio, is considered threatened with extinction in Wisconsin, and is extremely rare in Minnesota, Indiana, and New York.

In Illinois, the pugnose shiner is one of the rarest fishes. Originally described in 1885 from Fox River in McHenry County,

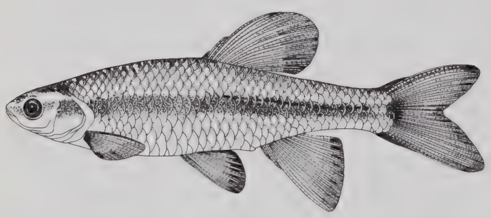
Pugnose Shiner (Drawing by Craig Ronto).

Illinois, the species was found in Fourth Lake in Lake County in 1892 and in a floodplain lake of the Illinois River in Mason County in 1909. Additional observations of the pugnose shiner (all in Lake County) were made in Channel Lake in

1965, and Loon Lake and Grass Lake in 1968. No observations of the pugnose shiner in Illinois were made between 1968 and 1984 and it was believed that it might already have disappeared from the state.

Nearly all of the natural lakes in northeastern Illinois, where most of the pugnose shiners have been found, now are surrounded by human dwellings and receive ever-increasing amounts of pollution. Many have had deliberate introductions of sport fishes, all of which are highly predatory and are known to alter the natural balance in predator-prey relationships. However, some lakes appear to remain in a sufficiently natural condition to support the pugnose shiner.

The bluehead shiner has a highly disjunct range, with the Illinois population being the only one found east of the Mississippi River and is far to the northeast of any other known population. In Illinois, it has been found only in Wolf Lake and in the contiguous LaRue Swamp, in Union County. It was first discovered in Wolf Lake in the mid-1950's and last observed there in 1974. Several recent attempts to document its continued presence have been unsuccessful, but Wolf Lake is an extremely difficult place to sample, and the species may still be present. LaRue Swamp



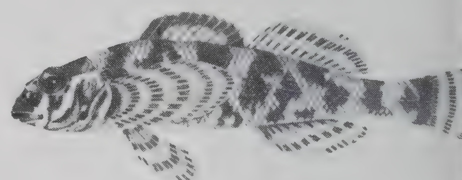
Bluehead Shiner

has been sampled many times in recent years, but the bluehead shiner has not been found, and its earlier presence there is assumed to have represented stragglers from Wolf Lake.

Wolf Lake is an old, deep, mud-bottomed oxbow of the Big Muddy River, margined with emergent and submerged vegetation. Elsewhere the species occupies similar lakes and backwaters of sluggish small- to medium-sized streams. Usually the habitat is heavily vegetated and has bottom of mud or sand. Other populatio of the bluehead shiner are known in A kansas, Louisiana, and Texas.

The harlequin darter also has a high disjunct range. The Illinois populatio now apparently confined to the Embarr River (and possibly the Wabash River), a relict of a more widespread populatio No harlequin darters have been found Indiana since 1890, and a similarly di junct population in the Patoka River Indiana now may be extinct.

The harlequin darter was discovered the Embarras River in 1964, and a fe specimens were found at several sites



Harlequin Darter

Cumberland and Jasper counties betwe 1964 and 1968. It was not seen again Illinois until 1983 when one was found the Embarras River below the Charlest Dam in Coles County.

Harlequin darters live in rocky riffles ar accumulations of leaves and debris ov sand or gravel in runs of small- to mediun sized rivers and large creeks. The species found sporadically from the Wabash Riv system in Illinois and perhaps Indian south in tributaries of the lower Mississip River to Louisiana, and in Gulf Coa drainages from the Escambia River in Flo ida to the Neches River in Texas. The sp cies seldom is common anywhere.

Although the Embarras River has bee dammed at Charleston, channelized in i lower reaches, and suffers from siltatio the stretch of the river from Charleston Newton retains an excellent variety habitats and supports large populations many fishes. The 1983 observation of harlequin darter in the river attests to th possibility of protecting the Illinois popu lation by protecting the river.

All localities in Illinois at which the

ıree species are known to have occurred ʼill be revisited in 1984-1985. Additional ɔcalities in Illinois which are within the eographic domain of the species and apear to have suitable habitat will be samıled also. Included in the results of the tudy will be an assessment of the status i.e., distribution and abundance) of each f the three species in Illinois, a description based on observations and published inormation) of the ecological requirements mportant for survival of the species, an asessment of the causes for the decline of the pecies in Illinois, and identification of ıabitats in Illinois critical to the continued urvival of the species.

Field work to date has located a population of the pugnose shiner in East Loon Lake in Lake County, and confirmed the continued existence of the harlequin darter n the Embarras River below Charleston Dam in Coles County. Researchers have been unable to locate bluehead shiners in Illinois; however, a search for this species n Horseshoe Lake in Alexander County, a lake similar in many respects to Wolf Lake, produced a cypress minnow, a species not seen in Illinois since 1940 and thought to have been extirpated from the state.

[Fish drawings were taken from *Fishes of Illinois* by Philip W. Smith.]

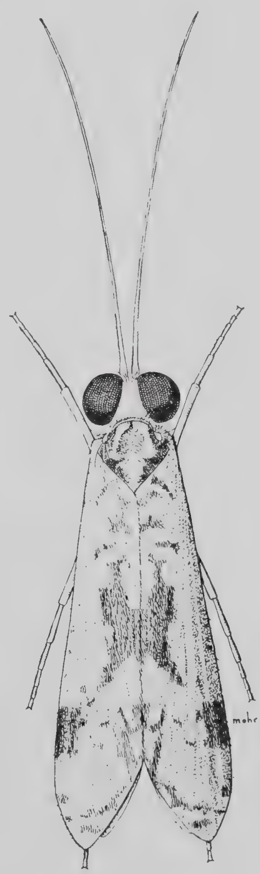
Caddisfly Systematics

The caddisflies comprise the insect order Trichoptera, containing nearly 10,000 species worldwide grouped in several hundred genera and approximately 35 families. Caddisflies are aquatic insects which live in lakes and streams. Survey entomologist J. D. Unzicker has been studying the systematics of the family Hydropsychidae, which occurs throughout the world.

Hydropsychid caddisflies are known as net-spinners because the immature stage or larva constructs a silken net or retreat to filter microscopic articles of food from moving water. Caddisflies are an integral and important part of the aquatic food chain in Illinois' streams and lakes.

Until recently hydropsychid genera have been diagnosed to a large extent on the basis of structures of the adult stage. Unzicker and a Canadian colleague have analyzed the 20 North American species of the genus *Symphitopsyche* using both adult and larval structures. Closely related species were clustered first on larval and then adult characters, and then the two sets of species groupings were compared. There was almost complete overlap of the clusters based on characters of two different life stages. This method provides a high degree of confidence in the characters selected as diagnostic for a genus in the Hydropsychidae.

Unzicker has already published a new alignment of eight North American genera in the subfamily Hydropsychinae, but an important problem remains to be solved. How do these eight genera fit with the 22 other genera occurring on other continents? He is now examining these 22 genera in the subfamily in order to find structures



Adult net-spinning caddisfly of the genus *Hydropsyche* (Drawing from *Caddisflies of Illinois* by Herbert Ross).

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in both the adult and larval stages which will be diagnostic for each genus. The combination of adult and larval characters provides valuable evidence for inferring psylogeny (i.e., history of the lines of evolution) and, if this is known, their diverse distributions should make possible the inference of past dispersal routes which have led to present day distributions of these genera. Unraveling the relationships of the many genera in the family Hydropsychidae is the goal of Unzicker's research.

The INHS/IDOT Program

The Natural History Survey has assisted the Illinois Department of Transportation (IDOT) for several years by conducting faunal and floral inventories and surveys of endangered and threatened species and natural areas likely to be affected by highway and bridge construction, replacement, or repair activities. A typical year has required 25 to 30 detailed studies, each needing from several days to months of investigation and research.

The Survey's program with IDOT was expanded in scope and number of studies to be conducted for fiscal year '85 to include two additional areas of responsibility. In the first, Survey scientists are mapping and evaluating soils, and determining the presence, characteristics, and extent of prime farmland and wetlands for each c 400 to 500 new highway projects per yea Scientists are also providing a preliminar screening of the biological resources t assess the need for additional study.

Recommendations for additional researc are one source of detailed studies suc as those performed in the original pro gram. Also, projects occasionally requir extensive investigation by a diverse re search team (such as the detailed botani cal, zoological, water quality, and soil research performed at the Morton Arbore tum). Such "special projects" are covere in the second new area of the INHS IDOT program, established to coordinat these extended studies.

Ten new Survey positions were create for this expanded program and are funde by contract from IDOT. These include biology assistants (2), botanists (2), soi scientist (1), soil mappers (2), biologist coordinator (2), and an administrative as sistant (1). Warren U. Brigham serves a Director of the INHS/IDOT program Project coordinators are Allison R. Brig ham, screening studies; Gene Ardner, de tailed studies; and Mark J. Wetzel, ex tended studies. Most of the staff and workload for this expanded program is in the Section of Faunistic Surveys and Insec Identification, with support from the Sec tion of Botany and Plant Pathology.

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NATURAL HISTORY

SURVEY REPORTS

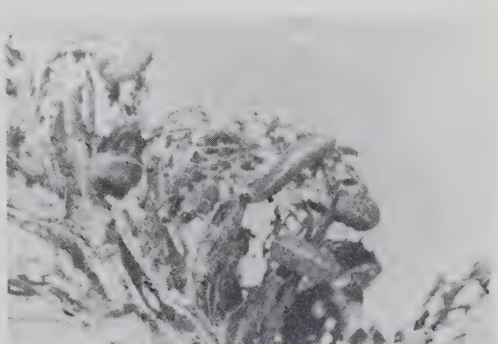
ɩn Epizootic in the Alfalfa?

Epizootiology, or the study of disease dy-amics in insect populations, is a relatively ew area of research. Three major factors re important in the development of epi-ootics, or epidemics: (1) a pathogen, or ıfectious agent; (2) a group of susceptible ısect hosts; and (3) an effective method f disease transmission among hosts. The cology of epizootics, and the environ-ıental factors that affect their develop-ıent, are important areas of research.

Economic Entomology staff members ⁄Iarilyn Morris and Michael McGuire are urrently studying fungal pathogens of the .lfalfa weevil and the potato leafhopper, wo major pests of alfalfa in Illinois. Cer-ain factors limit the effectiveness of each ›athogen in controlling pest populations, ınd neither pathogen is part of an existing llinois pest management program for al-alfa.

In the case of the alfalfa weevil patho-;en, *Erynia phytonomi*, disease epizootics ıave been observed routinely since the late 970's. The epizootics, however, often oc-:ur too late in the season to keep the weevil ›opulation below a crop-damaging level, o that chemical sprays are needed. This ate occurrence is characteristic of many ungal pathogens and can limit their pest-:ontrolling capabilities. One management trategy that could increase the effective-ıess of this pathogen is to cause the dis-:ase to begin earlier in the growing sea-on. Disease activity typically begins when ›ver-wintering resting spores germinate in he spring and begin the infection cycle in he host population. Genetic selection for :arlier resting spore germination could in-:rease the effectiveness of epizootics. Un-fortunately, the field conditions that pro-mote resting spore germination are poorly known. Survey researchers are examining the possible influences of temperature and photoperiod on germination.

Another method of inducing early dis-ease onset is to "seed" fields with cultures of the actively growing fungus early in the season. Conidiospores, released by the cul-tures and responsible for the spread of in-fection among insects, would infect suscep-tible hosts, allowing the disease to become established in the insect population earlier than usual. This method could also be used to establish the pathogen in an area where it does not exist. Using this method, an at-tempt was made to establish the potato leafhopper fungus, *Erynia radicans*, in Illi-nois. While this fungus is present in Wis-consin, it has never been found in Illinois. Sporulating cultures of *E. radicans* were introduced into potato fields where unin-fected potato leafhoppers were present. Al-though cultures produced many spores, subsequent sampling yielded only a few



Healthy alfalfa weevil larvae and larvae infected with the pathogenic fungus, *Erynia phytonomi* (Photo by Marilyn Morris).

infected leafhoppers and the infection soon disappeared from the field.

The failure of *E. radicans* to become established may be due to adverse environmental conditions. Environmental factors play a very important role in the development of epizootics and can limit or enhance the growth and spread of pathogens. For fungal diseases, high humidity is considered to be among the most important requirements for spore formation and germination. If humidity is adequate, temperature may be a limiting factor. Growth studies have shown that *E. radicans* grows poorly, or not at all, at the high temperatures common during the midsummer in Illinois alfalfa fields, when potato leafhoppers are abundant. The inability to develop at high temperatures may explain why the introduction of the pathogen into Illinois fields was unsuccessful. The selection and subsequent introduction of fungal strains that can grow and infect leafhoppers at higher temperatures may facilitate the use of this fungus for biological control. *E. phytonomi,* the alfalfa weevil fungus, also grows poorly at high temperatures. However, the susceptible stage of the weevil is present in Illinois in late spring, and the typically cool temperatures at that time allow for fungal growth and the observed epizootics.

In addition to initial infections and favorable environmental conditions, a threshold population of susceptible hosts and an efficient means of disease transmission are also needed for an epizootic to develop. For the alfalfa weevil and its associated fungus, *E. phytonomi,* approximately two weevils per alfalfa stem must be present before an epizootic will develop. This population level is very close to the weevil density above which insecticidal spray treatments are applied. In order to avoid the use of chemical sprays and maximize the role of the pathogen for insect control, certain agricultural cropping methods that increase the transmission efficiency of the fungus can be employed. An early first harvest of alfalfa, timed to coincide with the first incidence of diseased larvae could concentrate weevil larvae on the stubble and, by removing the alfalfa foliage, allow the airborne spores to spread more readily the remaining weevil population.

Before either of these two insect path gens can be used effectively in Illinois a riculture, additional laboratory and fie studies are needed. Both enhancement the naturally occurring alfalfa weevil fu gus, or introduction of a more suitab strain of the potato leafhopper fungus, w require a thorough understanding of th factors that influence the growth an spread of disease in populations of the alfalfa pests.

Analysis of Fish Communities in Illinois Impoundments

Fishing is one of the most popular pa times in the state. Annual license revenu from Illinois residents have exceeded 4 million dollars since 1980. Angling pre sure has increased at a faster rate than th construction of new impoundments, an has affected fish populations significant compared with natural causes.

Typical Illinois impoundments are ve productive, so management is not nece sarily the stocking of new fish, but influ encing the natural productive processes provide the size and species of fish desire by the angling public. Stocking of fish usually expensive, but can sometimes b justified in particular cases, such as (1 when an impoundment has to be ren vated, (2) for desired species outside the natural range when they cannot surviv throughout the year (e.g., trout), or (3 for species which cannot reproduce or r cruit successfully in the artificial enviro ment of an impoundment (e.g., chann catfish).

There are two extreme approaches management. The first is to act on a hunc or some unquantified previous experienc The second is to follow a prediction base on a model of the system which is in tur based on quantified previous experience. I practice, recreational fisheries manageme operates somewhere between these e tremes, but typically close to the first. Onc the experience has been gained, a goo manager can succeed in this manner, bu the experience cannot easily benefit a ne manager, or other managers working wit

similar fish communities in other impoundments, or policy makers who need to allocate resources statewide. Also, since the previous information often was not quantified or recorded, the ability to detect and correct an adverse change in the fish populations and evaluate the results of management was impaired.

To approach the second more scientific extreme requires an investment in (1) organizing a system of standardized sampling to facilitate comparisons, (2) calibrating the sampling methods under various conditions to provide unbiased measures of the fish populations, and (3) data management systems to assist managers and permit assembly of statewide data for predictive model construction and provide data for statewide resource allocation. The benefits will be both in short-term management strategies at the local and state levels, and in our scientific understanding of fish communities in impoundments, which through predictive models can assist in long-term management and future short-term decisions.

In summary, we need to increase benefits in terms of angler satisfaction by making the management process closer to biological and fiscal reality. Human resources are required which have recreational, research, and direct field sampling perspectives. Such resources are available at the Illinois Department of Conservation (DOC) and the Illinois Natural History Survey.

A project was designed and initiated by Peter Bayley in January 1984 to: (1) make the individual data sets comparable without losing the unique characteristics of each water body; (2) calibrate the standardized sampling techniques so that we can produce estimates of abundance, biomass, and biological production of fish, which are prerequisites for realistic predictive models; (3) ultimately be able to relate all the data sets for across the State with other influencing factors, such as fishing pressure, natural effects, and anticipated demands on the resource; and (4) develop a system to periodically summarize the findings so that optimal management decisions can be made.

Existing fish sampling facilities and personnel at both the DOC and the Survey and existing computers at the Survey will be utilized. Additional microcomputers are being purchased for permanent installation with DOC District Biologists who manage impoundments, and software development is underway. The project is supported by the federally administrated Dingel-Johnson fund which depends on a tax based on fishing tackle purchases. Although the project is funded for 3 years, the system of data acquisition, storage and analysis will be permanent, and the benefits will accrue over many years.

Bacterial Populations in Two Pools of the Mississippi River

Bacterial populations associated with aquatic plants in Pools 19 (Keokuk) and 26 (Grafton) of the Mississippi River represent a significant portion of the total amount of bacteria available to consumers in the pools. Bacteria contribute to the food web by transforming dissolved organic carbon released from living plants into bacterial biomass and by aiding in the decomposition of dead plant parts.

As a part of the Long-Term Ecological Research (LTER) Large Rivers study, Michael S. Henebry and Robert W. Gorden are using direct microscopic counts to estimate the amount of bacteria in the water column, in sediments, and on the surface of plants in different habitat types in Pools 19 and 26. Water, sediment, and plant samples were collected from 37 sites along eight across-the-river transects in Pool 19 in August and October 1984. Location, water depth, sediment type, and presence or absence of rooted aquatic vegetation were used to classify sites as either

Typical vegetation bed being studied is American lotus, *Nelumbo lutrea* (Photo by Mike Henebry).

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main channel, main channel border, vegetated main channel border, or side channel habitats.

Bacterial cell sizes and numbers in Pool 19 water samples were similar to those found in other freshwater systems. Bacterial populations at vegetated main channel border sites were significantly higher than those at main channel sites. The numbers of bacteria on aquatic plants such as arrowhead (*Sagittaria*) and eelgrass (*Vallisneria*) were higher than numbers in the water column and sediments.

To compare the total bacterial biomass in vegetated areas of the pool to that in areas without plants, values from the water column, sediments, and on macrophytes were converted to number of grams of carbon per square meter and then multiplied by the habitat area to yield total biomass as kilograms of bacterial carbon. Although at low flow only 7 percent of the total water area in Pool 19 is in the vegetated mai channel border habitat, that habitat sup ported 16 percent of the bacterial biomas

Data suggest that organic matter, pro duced in the plant beds and processed b bacteria is transported into vegetationle areas via current and wave action. A though the vegetated area of Pool 19 relatively small, the decomposing plant ma terial and associated bacteria are importan sources of carbon and energy (nutrition for consumers, such as the abundant popu lations of mayflies (*Hexagenia*) and finge nail clams (*Musculium*) in adjacent mai channel border areas without vegetation.

Determination of the source of nutritio for the large populations of mayflies an fingernail clams is an important step i explaining the high productivity of poole reaches of the Mississippi River. This re search will continue in the summers c 1985 and 1986.

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NATURAL HISTORY
SURVEY REPORTS

JUNE 1988, NO. 248

ıquatic Plant Research and Management

Infestations of aquatic plants in ponds, ıkes, and reservoirs in Illinois have in-reased dramatically during the past 30 ears, due largely to increased nutrient in-uxes and the establishment of exotic spe-ies. Concurrently, there has been an in-reased demand for recreational and in-ustrial uses of our water resources; these ses may be severely restricted by dense tands of aquatic plants. Therefore, safe, ffective, and affordable aquatic plant con-rol technologies are needed.

As part of the Aquatic Macrophyte Re-earch Program at the Illinois Natural His-ory Survey, Pamela P. Tazik, Michael J. Viley, and their associates are formulating n effective, ecologically safe, and compre-ıensive aquatic plant management pro-ram for Illinois; to do so, the basic biology ınd ecology of aquatic plants must be un-lerstood. As a first step, they have identi-ied the nuisance aquatic plants in Illinois ınd evaluated the effectiveness of current ontrol methods.

Although Illinois has many aquatic lants that may reach nuisance propor-ions, generally a few species cause most of he problems. American elodea (*Elodea anadensis*), water milfoil (*Myriophyllum* pp.), coontail (*Ceratophyllum demer-um*), naiads (*Najas* spp.), and pondweeds (*Potamogeton* spp.) are the primary prob-em plants in Illinois, infesting waters hroughout the state.

Of the three basic aquatic plant control trategies (chemical, mechanical, and bi-logical), the most commonly used in Illi-ıois is chemical control. Seasonal control of ondweeds and naiads can usually be ob-ained through herbicide application, but coontail, American elodea, and water mil-foil often are not controlled effectively by herbicide application. Herbicides are ex-pensive and require annual (or sometimes semi-annual) application; they may also be toxic to non-target aquatic organisms with improper application.

Potamogeton spp., one of the commoner nuisance pondweeds found in Illinois waters (Photo by Wilmer Zehr).

Mechanical control, such as harvesting, shading chemicals, fertilization, and ben-thic barriers, are used to a limited extent in Illinois. This type of control may be appropriate for ponds and small areas of lakes and reservoirs, but it is often pro-hibitively expensive if used in a large-scale application. Like aquatic herbicides, me-chanical control methods provide short-term or seasonal control.

Biological control is not widely used in Illinois, but it holds considerable promise for future application. With biological con-trol, an organism is introduced that will

inhibit or control the growth of aquatic plants. Herbivorous fish, mammals, invertebrates, and microorganisms are all possible bio-control agents. Unlike the other available methods, biological control may be effective over many years. The herbivorous grass carp (*Ctenopharyngodon idella*) is the most widely used and studied bio-control agent for aquatic plants. These fish have a tremendous feeding and growth capacity, making them a potent control agent. However, those traits also make them a serious potential pest, especially if they become established in the large rivers where they could reproduce. Consequently, grass carp are illegal currently in Illinois.

Two genetic derivatives of the grass carp have been produced since the late 1970's, the hybrid carp (female grass carp x male bighead carp) and the triploid grass carp (two grass carp parents). Shortly after production of these fish began, the Illinois Natural History Survey initiated a study to determine: (1) their effectiveness in controlling aquatic plants, (2) their reproductive potential, and (3) the environmental impacts associated with their use. That study indicated that neither the hybrid nor the triploid grass carp could reproduce, but only the triploid grass carp retained the plant-eating capabilities of the grass carp. The development of these sterile herbivorous carp, particularly the triploid, has made bio-control feasible and acceptable for use in Illinois. Wiley, Tazik, and associates have recommended the legalization of the sterile, triploid grass carp and have developed a computer-implemented model to aid in stocking recommendations. When these fish are legalized, Illinois citizens will be able to stock the triploid grass carp as an ecologically sage aquatic plant management mechanism.

"People" Diseases of Trees

Some of the most destructive diseases of trees are caused by humans. In spite of the amount of money and effort used to plant and maintain their trees and shrubs, some persons are unknowingly responsible for the injury and death of their trees.

Common person-caused injuries to trees are often related to construction and the building of additions to homes. Constru tion damage includes (1) actual mechan cal damage from heavy equipment scarrir the trunk and branches and cutting off th roots, (2) causing grade changes by eith removing soil or placing soil over the root (3) changes in the water table by ditchir and draining in developing subdivisions in homesite developments, and (4) trencl ing and ditching close to established tre that sever large areas of the trees' ro systems.

Soil compaction from running hea equipment over the soil, especially durir wet periods of the year, is destructive both the soil structure and to the roots the trees. The compacted soil will rema deficient in essential oxygen for proper ro respiration, and water will not penetra a hard soil surface for several months. Gra will do poorly in compacted soil, and tre and shrubs will often die.

When the soil is compacted arour established trees, a 3- to 4-inch layer woodchip mulch placed over the root ar will help the soil to restructure and becon less compacted over a shorter period time than if reseeded to bluegrass. A type of cultivation to loosen the compact soil around established trees will be d structive to roots that normally develop the upper 4 to 6 inches of the soil. Th more shallow roots are essential to th proper uptake of nutrients and water most urban tree species.

Excessive pruning out of large branch of trees having roots injured during co struction is not recommended. A profe sional arborist should be consulted befo construction begins, and should be retain to help maintain the trees after constru tion is completed. Trees can be saved a maintained in a vigorous condition wi proper and timely professional advice a care.

New Publication on Shorthead Redhorse

A multidisciplinary aquatic monitori program has been conducted in the Ka kakee River near Wilmington, in an eff to characterize the segment of river ne Commonwealth Edison's intake and d charge structures for the Braidwood St

ion. The study area includes a variety of abitats including Horse Creek, a small ributary. Different assemblages of fishes opulated the various habitat types.

The Shorthead redhorse, *Moxostoma nacrolepidotum,* is one of the important nd least known river fishes and its biology s detailed in the recently published Bioogical Notes No. 123, "The Life History f the Shorthead Redhorse, *Moxostoma nacrolepidotum* in the Kankakee River Drainage, Illinois."

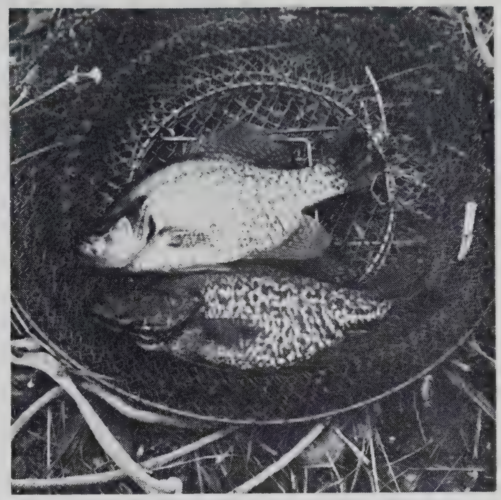
The species was studied intensively durng May, August, and November of 1977, 978, and 1979 and in August of 1981 and 982. Supplementary collections were made luring other ice-free months. The shortead redhorse was a dominant fish in elecrofishing collections. Large numbers of ish collected in August 1981 were the reult of two strong year classes and high vater levels that increased the susceptibility of the fish to shoreline electrofishing. Preerred habitats were cobble areas in waters 1-2 m deep with velocities of 23-63 cm/sec. Shorthead redhorse began to gather in a tributary, Horse Creek in early March and spawned in late April and early May. On April 30, 1979, 81 reproducing males and 27 females were collected in Horse Creek. Approximately 3,000 shorthead redhorse were present in a single raceway-riffle area of Horse Creek at that time. Each female produced an average of 18,000 eggs. A low recovery rate of tagged individuals indicated extensive movement and dispersion of this species from the monitoring area.

The foods eaten, types of Chironomidae (midge larvae) consumed, and a lack of burrowing mayflies in the diet suggested that shorthead redhorse fed in riffles and riffle margins.

Copies of this publication may be obtained by writing to the Chief of the Illinois Natural History Survey.

Hybrid Crappie Study

The black and white crappies are two of our most colorful and attractive fishes, and two of the most sought after by anglers. In their classic treatment of Illinois Fishes, Forbes and Richardson (1908) noted that both crappies ranged over all of Illinois,



Black and white crappie (Photo by George Bennett).

and over much of the eastern U.S. and southern Canada. The white crappie was found abundantly in "lakes, ponds, and bayous," but were plentiful also in the smaller rivers and creeks. Black crappie shared many of the same waters, but were less abundant generally than the white, showing an affinity for cooler, less turbid waters. Present distributional patterns are similar: the white is common in impoundments, both large and small; while the black has an irregular distribution in the larger reservoirs and is less common in smaller impoundments. Both may maintain relatively stable populations in large impoundments, but tend to overpopulate when stocked in small impoundments and farm ponds.

Overpopulation leads to stunting and severe competition with bass and bluegill. Many management strategies have been employed, including introduction of forage species to increase the crappie food supply, reduction of crappie numbers by various chemical or mechanical means, and use of large predators such as largemouth bass and northern pike. However, failure to develop dependable strategies for small impoundments has led managers in most of our states to forego the crappies for more manageable species. In Illinois, management recommendations now exclude crappies from farm ponds, and most biologists now favor their elimination in all impoundments smaller than 250 acres. It is

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recognized, however, that crappies are highly favored by anglers, and that a solution to the problem could increase sportfish harvests in thousands of small impoundments where crappies are now a problem, or have been excluded.

The late W. F. Childers, long-time Survey biologist, was probably the first to suggest that hybrid crappies might at least minimize the "crappie problem," and was the first to produce hybrid crappies in the laboratory and to stock them experimentally. Childers believed that natural hybrids occurred widely in Illinois, and that several 4- to 5-pound crappies examined by him were all hybrids. He believed also that hybrid crappies grow faster than either parent, and might be less inclined to overpopulate, but he never completed his investigations.

Current studies by Survey biologists Homer Buck and Mike Hooe are the first involving hybrid crappies since the pioneer work by Childers. The principal studies are being conducted in the laboratory and in earthen ponds at the Sam A. Parr Fisheries Research Center near Kinmundy. Genetic identities of experimental fish are determined by starch-gel electrophoresis in the Survey fish genetics laboratory supervised by David Philipp. The basic purpose of the investigation is to evaluate hybrid crappies as sportfish. Half-sibling hybri and pure stock crappie fry were produce in the laboratory by stripping eggs from female and fertilizing half with milt fro a black crappie, and half with milt from white crappie. Natural hybrids were pro duced also in ponds by isolating males c one species with females of the other. Bot interspecific F_1 hybrids have made signifi cantly faster first-year growths than eithe parent when sharing the same environ ments in all populations studied, and pre liminary analyses indicate that second-yea growths by F_1 hybrids may also be superio to that of either parent. The reciprocal F hybrids were found to be indistinguishabl and to more closely resemble the blac parent than the white. Morphological dif ferences between the F_1 hybrids survived i significantly greater numbers than white when stocked as fry, and F_1 hybrids an black crappies survived seining, netting and handling much better than whites. A F_1 populations examined had 50:50 se ratios, and a male F_1 hybrid backcrosse with a white female crappie. Future studie will evaluate later generations of hybrids i terms of growth, fecundity, catchability and their ability to sustain desirable, fish able populations in small impoundment also containing desirable populations c largemouth bass and bluegills.

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DR. PAUL G. RISSER, CHIEF, ILLINOIS NATURAL HISTORY SURVEY, DEPARTMENT OF ENERGY AND NATURAL RESOURCE ESOURCES ILDING, 607 EAST PEABODY DRIVE APAIGN, ILLINOIS 6

NATURAL HISTORY
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SEPTEMBER 1983, NO. 239

all Food Habits of Mallards Illinois, 1979-1982

Illinois is a major migration area for aterfowl in the Mississippi Flyway. The st comprehensive study of the food habits waterfowl during fall migration in Illinois was conducted in 1938-1940. Since ıen, the wetlands and croplands of the [idwest have undergone dramatic changes.

During the hunting seasons of 1979-982, Survey researchers Stephen P. Hav-a and G. Alan Perkins collected 9,300 ıallard gizzards by weekly periods from 3 sites throughout Illinois. Emphasis was laced on the mallard because it comprises pproximately 86 percent and 47 percent waterfowl use in the fall in the Illinois ıd Mississippi river valleys, respectively, ıd makes up about 50 percent of the Illinois duck harvest. The mallard gizzards ere examined to determine (1) the prinpal foods used, (2) changes in food abits since 1940, (3) variation of major ɔod items within the state, and (4) variaon of food habits within and among ears.

The researchers identified a variety of ɔod items in the gizzard contents, includıg 300 plant species, 65 invertebrate taxa, ıd one vertebrate group. Examination of ɔod habits indicated that the Illinois River gion and Mississippi River region borderıg central Illinois received similar use by ıallards of corn (48 percent and 49 per-ent by aggregate volume, respectively). orn is generally available to mallards as aste grain in agricultural fields or on reas managed for waterfowl. The volumes moist-soil plant seeds were also similar gizzards collected from the Illinois River 25 percent) and the Mississippi River (20 percent). Moist-soil plants are naturally occurring annual plants that become established on exposed mud flats during the summer months.

There were some striking differences, however, in diets of mallards using the Mississippi and Illinois river valleys. Managed or cultivated agricultural foods, such as buckwheat, Japanese millet, and milo represented 10.5 percent of the diet on the Illinois River as compared with only 1.3 percent for the Mississippi. In contrast, submergent and emergent aquatic plants such as coontail and pondweeds were more prevalent in mallard gizzards from the Mississippi River (10.1 percent) than in those collected from the Illinois valley (trace). These differences can be explained by the virtual elimination of aquatic plants from the Illinois River as a result of sedi-

Mallard ducks are pictured migrating through Havana looking for food, usually the gleanings of a corn field (Photo by W. E. Clark).

mentation and its devastating effects on aquatic communities during the past three decades. The degradation of the aquatic habitat via sedimentation has not been as severe in the Mississippi River. Consequently, aquatic plants are still common among mallard diets in the Mississippi River valley, but they have been replaced in the diets of mallards frequenting the Illinois River by cultivated agricultural foods provided on private and public-managed waterfowl areas.

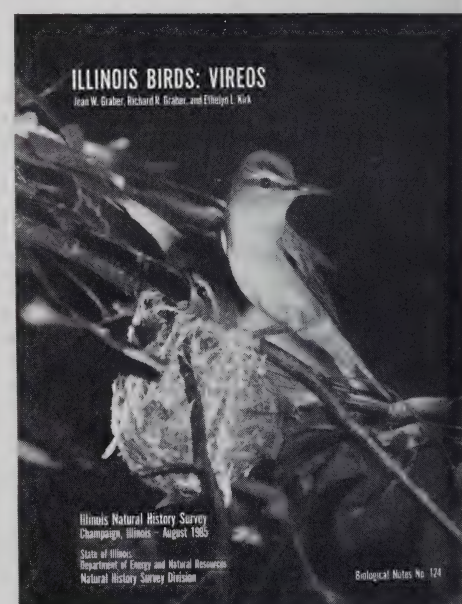
Similar results appeared when the mallard food habits from the Illinois River valley were compared between 1938-1939 and 1979-1982. During both periods, corn was the leading food item (48 percent during both periods) followed by moist-soil plants (24 percent versus 25 percent, respectively). However, the managed agricultural foods of Japanese millet, buckwheat, and milo did not occur in the mallard diets of 1938-1940, whereas aquatic plants represented 15 percent of the diet. In 1979-1982, managed agricultural foods represented 10.5 percent of the diet of mallards, but aquatic plants were essentially non-existent. Migrant mallard populations using the Illinois valley are now heavily dependent upon waste grain and managed foods while increasing their body reserves before resuming their southward trek toward wintering areas.

Analyses of mallard diets also uncovered another interesting finding. Generally the amount of corn in the diet increased during the fall in most regions of Illinois. For example, the percentage of corn in the diet increased from an average of about 35 percent in late October in the Illinois valley to about 65 percent by early December. Corn contains a high percentage of carbohydrates and, therefore, is relatively high in energy content, but many natural foods provide similar caloric values. However, a large amount of corn can usually be eaten quickly and satisfy mallards' energy requirements in a short period of time. The late season switch to corn did not occur in the diet of mallards using the confluence region of the Illinois and Mississippi rivers. In the confluence region, seeds of moist-soil plants made up approximately 50 percent of the diet throughout the fa[ll], whereas corn consisted of only about [...] percent. Apparently natural vegetation w[as] so abundant in this region that mallar[ds] did not utilize corn to the same degree [as] in other areas of Illinois. This findi[ng] might provide some insight into the di[et] of mallards in mid-latitude migration are[as] before corn was cultivated in presettleme[nt] times. Perhaps corn is replacing acorns a[nd] other mast that is no longer available [to] mallards as it once was in the vast expan[se] of timber that graced the bottomlands.

Tenth Bird Publication Available

"Illinois Birds: Vireos," Biological No[te]s No. 124 published in August, is the m[ost] recent publication of the Illinois Natu[ra]l History Survey. This paper is the tenth [in] a series on Illinois birds written by Jean [W.] Graber, Richard R. Graber, and Ethelyn [L.] Kirk. In some other reports in the seri[es], Richard R. Graber was the senior auth[or].

According to the authors, seven spec[ie]s of the Vireo family occur in Illinois, o[ne] — the Philadelphia — only as a transie[nt] in spring and fall. Another species — t[he] solitary vireo — has been found nesti[ng] only at Sand Ridge State Forest and occu[rs]



Tenth bird publication in a series by the Grabers [and] Ethelyn L. Kirk.

ı the state primarily as a transient. The ther five species nest regularly in Illinois nd occur also as migrants. They are ıe white-eyed vireo, Bell's vireo, yellow-ıroated vireo, the warbling vireo, and the ·d-eyed vireo.

As in the earlier bird Biological Notes, ıe emphasis is on population dynamics nd habitat relationships, not their taxo-omy. Where no authority is cited for a ·cord, the record is the Grabers'. Sexual imorphism in plumage is essentiallly lack-ıg in vireos, and reference to sex in the eld observations are based on behavior, specially singing.

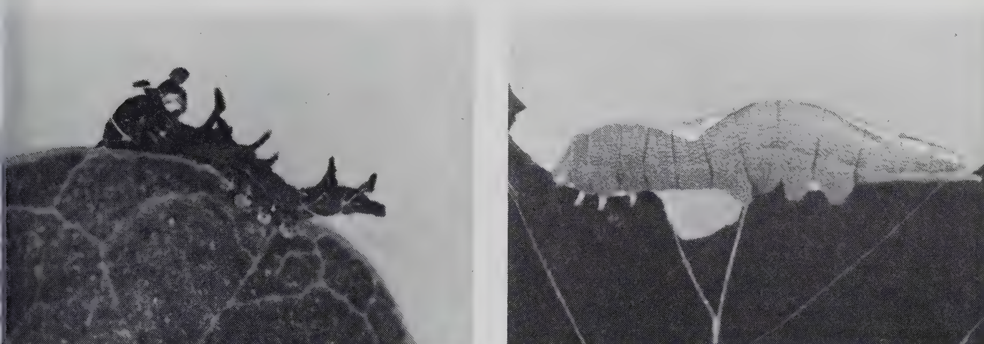
The paper discusses not only the distri-ution of the various species in Illinois, but lso maps their general distribution in the Jnited States. Other data include informa-on about egg laying and migration sea-ons, nesting habits, food preferences, and honetic interpretations of the birds' song. The excellent photography was done chiefly y the authors and shows close-ups of most f the birds on their nests.

Books included in the series are Biological Notes No. 68, 1970, "Illinois Birds: Mimidae"; Biological Notes No. 75, 1971, "Illinois Birds: Turidae"; Biological Notes No. 80, 1972, "Illinois Birds: Hirundinidae"; Biological Notes No. 83, 1973, "Illinois Birds: Laniidae"; Biological Notes No. 86, 1974, "Illinois Birds: Tyrannidae"; Biological Notes No. 102, 1977, "Illinois Birds: Picidae"; Biological Notes No. 109, 1978, "Illinois Birds: Ciconiiformes"; Biological Notes No. 110, 1979, "Illinois Birds: Syviidae"; and Biological Notes No. 118, 1983, "Illinois Birds: Wood Warblers."

These publications are available upon request to Chief Paul Risser, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, Illinois 61820.

Forest Caterpillars

Notodontid caterpillars feed almost exclusively on the foliage of broad-leafed shrubs and trees in natural and maintained settings. Several species, including the variable oakleaf caterpillar (*Lochmaeus manteo*), redhumped oak worm (*Symmerista albifrons*), walnut caterpillar (*Datana in-*



ırst larval stage (left) and last larval stage (right) of *Heterocampa obliqua* (Photo by G. L. Godfrey).

ıst larval stage of *Ellida caniplaga* following moult (left) and 32 hours later (right) (Photos by G. L. Godfrey).

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tegerrima), and saddled prominent caterpillar (*Heterocampa guttivitta*) are notable defoliators. As leaf eaters, notodontids are well adapted to an arboreal habitat and have some very interesting ways of avoiding would-be predators and parasitoids. These include chemical (some species are capable of spraying formic acid), physical (synchronized head and tail jerking by gregarious species), and cryptic (resemblance of whole, partly eaten, twisted, or tattered leaves) defenses.

During the course of larval development, i.e., the growing and moulting process, some notodontids exhibit remarkable changes in body shape and/or coloration. Two examples of this are illustrated by *Heterocampa obliqua* which feeds on various species of oak, especially white oak and burr oak, and *Ellida caniplaga* which occurs on basswood.

The first larval stage of *Heterocampa obliqua* is adorned with branched, antler-like tubercles and is nearly solidly colored. The "antlers" disappear after the first moult, and the subsequent larval stages are evenly contoured and distinctly patterned. There virtually are no clues to indicate that the latter larval stages represent the same species as does the first stage. *Ellida caniplaga* maintains the same basic body shape during successive larval stages but undergoes a distinct intensification of coloration during the first 24-32 hours afte moulting into the last stage.

There is a basic change in the feedin behavior associated with larval develop ment. Entomologists have long known tha an early stage notodontid caterpillar skele tonizes the leaf on which it feeds (it ea into the flat surface of the leaf blade, re moving soft tissues and leaving the veinle and veins), but that an older caterpilla moves to the leaf's edge where it remove strips of tissue. Survey entomologist, Georg L. Godfrey, is showing that this switch correlated with a change in the adaptiv design of the mandible. The mandibles c the more advanced stages are smooth an are used for clipping. The loss of teeth not attributable to wear.

The basic purpose of Godfrey's study c the developmental morphology and th feeding behavior of notodontid caterpilla is an attempt to understand more clearl the phylogenetic relationships among th notodontid species and between them an the related noctuids (armyworms, cu worms, and green fruitworms). This wor is being done in collaboration with fello Survey entomologist, James E. Appleby, t enhance the recognition of all larval stag for selected notodontid species during th development of management programs fo Illinois forest insect pests.

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NATURAL HISTORY
SURVEY REPORTS

OCTOBER 1985, NO. 250

es Plaines River Microorganisms

Since the passage and enforcement of ws regulating point sources of pollution :.g., power plant effluents and discharges om sewage treatment plants), contami- ation of many rivers and streams in Illi- ois has been reduced. However, because : numerous nonpoint sources of pollution :.g., topsoil runoff from agriculture and oad construction), habitats for plants and nimals have not been restored and the ariety of native species found in our water- ays has decreased. The Des Plaines River nd its natural floodplain in the Lake ounty Forest Preserve in northern Illinois rovide good examples of relatively "clean" abitats that are degraded because of ream channelization and excessive silta- on.

In spring 1985, the Des Plaines River /etlands Demonstration Project was initi- ted by Dr. Donald Hey of Wetlands Re- earch, Inc., to determine if the diversity of lants and animals could be enhanced by :-creating a wet prairie habitat along the river, reducing the river's silt load, and increasing the diversity of aquatic and terrestrial habitats. The Des Plaines River will be diverted through a series of restored marshy wetlands, which should remove much of the silt load. The clarified water from the experimental wetlands will then flow through two quarry lakes to increase their nutrient supply, and ultimately increase fish production.

wo researchers gather samples from the Des Plaines ver (Photo by Virginia Henebry).

As part of a multi-disciplinary team, Michael Henebry and Robert Gordon, Aquatic Biology Section, collected baseline data on the microbial populations (algae, bacteria, and Protozoa) in the Des Plaines River, its associated wetlands, and the quarry lakes, to help determine if the site is now receiving sewage or other forms of organic pollution.

Bacterial types, numbers, and biomass in water column samples were comparable to those found in silt-laden, but otherwise unpolluted, sites. The variety and total numbers of Protozoa, which feed on bacteria, were also low. The number of algal species and the population abundance of algae in the river and quarry lakes were well within the range expected for heavily silted rivers or unproductive lakes. Algal populations at the river sites were probably limited by light penetration through high levels of suspended solids. In quarry lakes, where water turbidity was low, algal abundance was significantly higher but was still limited by low nutrient levels. The production of algae in both the river and quarry lakes was too low to provide an adequate base for abundant higher organisms, such as fish.

In summary, there was no microbiological evidence of significant amounts of sewage pollution or organic enrichment at the project site. On the basis of indicator bacteria and total microbial populations, both the Des Plaines River and the quarry lakes were relatively unpolluted and unproductive.

The abundance and variety of bacteria, algae, and Protozoa is expected to increase in the proposed experimental wetland areas because of increased retention of nutrients and improved water clarity. The wetland plants will also act as attachment sites for microorganisms; this additional periphyton colonization and primary production should result in the production of important fish species.

Catalogs, Life Histories, and Bibliographies

In a dedicated effort to enable the citizens of Illinois to make the best possible use of its natural resources, the Illinois Natural History Survey conducts a wide variety of research projects related to the biological populations and ecosystems of the state. Much of this research is of a rather specialized nature and deals with sophisticated laboratory equipment, exotic field measuring devices, or complex theoretical and analytical techniques. Examples might include the tracking of migrating insects with radar or computer simulation models connecting fish behavior with telemetry data on dissolved oxygen levels in streams.

However, one of the unique features of the Survey is its long-term run of biological and ecological processes. This has resulted in many publications which are definitive benchmarks on the plants and animals of the state and future evaluations of the natural resources will be based on these fundamental life-history studies.

Since the early years of its 127-year existence, the Survey has made extensive studies of the Illinois flora and fauna which are probably better known than in any other state. Much of the resulting knowledge has been offered in life-history studies, catalogs, and bibliographies which conveniently organize information about species and habitats.

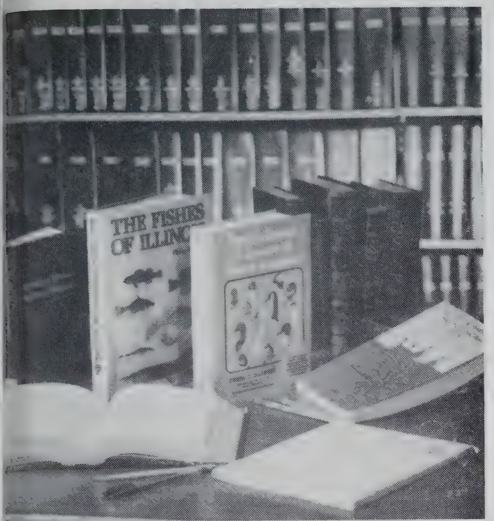
CATALOGS AND LIFE HISTORY STUDIES — VERTEBRATES

Amphibians and reptiles (Smith 1961)

Birds (Ridgeway 1881, 1889, 1895)
- Ciconiiformes (Graber, Graber, and Kirk 1978)
- Ducks, geese, and swans (Bellrose 197
- Geese (Hanson and Jones 1976)
- Hirundinidae (Graber, Graber, and Kirk 1972)
- Laniidae (Graber, Graber, and Kirk 1973)
- Mimidae (Graber, Graber, and Kirk 1970)
- Mourning dove (Hanson and Kossack 1963)
- Picidae (Graber, Graber, and Kirk 1977)
- Pheasants (Labisky 1975), (Warner 1981)
- Prairie-chicken (Yeatter 1943), (Westmeier 1980)
- Prothonotary warbler (Loucks 1894)
- Sylviidae (Graber, Graber, and Kirk 1979)
- Tyrannidae (Graber, Graber, and Kirk 1974)
- Turdidae (Graber, Graber, and Kirk 1971)
- Vireos (Graber, Graber, and Kirk 198
- Wood warbler (Graber, Graber, and Kirk 1983)

Cottontail rabbit (Lord 1963)

Fish
- Bantam sunfish (Burr 1977)
- Blackside darter (Thomas 1970)
- Cavefish (Smith and Welch 1978)
- Cypress darter (Burr and Page 1978)
- Darters (Page 1983)
- Dusky darter (Page and Smith 1970)
- Fishes (Jordan 1878), (Forbes and Richardson 1920), (O'Donnell 193 and (Smith 1979)
- Knothead carp (Thompson 1928)
- Least darter (Burr and Page 1979)
- Logsperch (Thomas 1970)
- Mud darter (Cummings, Grady, and Burr 1984)
- River darter (Thomas 1970)
- Shorthead redhorse (Sule and Skelly 1984)
- Slabrock darter (Page and Burr 1976)



Some publications of Survey scientists (Photo by Les Woodrum).

Slenderhead darter (Thomas 1970), (Page and Smith 1971)
Slough darter (Braasch and Smith 1967)
Spottail darter (Page 1974)
Stripetail darter (Page 1975)
Warmouth (Larimore 1957)
White crappie (Hansen 1951)

Fox and gray squirrels (Brown and Yeager 1945)

Mammals (Hoffmeister and Mohr 1957)

Reptiles and amphibians (Garman 1892)

White-tailed deer (Pietsch 1954)

CATALOGS AND LIFE HISTORY STUDIES — INVERTEBRATES

Agromzidae (Mulloch 1921)
Ants (Ross, Rotramel, and LaBerge 1971)
Bees (Schrader and LaBerge 1978)
Butterflies (Irwin and Downey 1973)
Caddisflies (Ross 1944)
Crayfishes and shrimps (Page 1985)
Damsel flies (Garman 1917)
Dermoptera and Orthoptera (Hebard 1934)
Dragonflies (Needham and Hart 1901)
Hirudinea (Moore 1901)
Jassidae (Woodworth 1887)
Land snail (Baker 1939)
Leafhoppers (DeLong 1948)
Mosquitos (Ross 1947)
Mayflies (Burks 1953)
Molluscs (Baker 1906)
Oribatoidea (Ewing 1909)
Orthoptera (Thomas 1876)
Pentatomoidea (Hart 1919)
Plant bugs (Knight 1941)
Plant lice (Hottes and Frison 1931)
Pseudoscorpions (Hoff 1949)
Scorpionflies (Webb, Penny, and Marlin 1975)
Soybean insects (Kogan and Kuhlman 1982)
Soybean spiders (LeSar and Unzicker 1978)
Stoneflies (Frison 1935)
True flies (Pechuman, Webb, and Tesky 1983)
Treehoppers (Goding 1894)
Terevidae (Irwin and Lyneborg 1980)
Thrips (Stannard 1968)

LIFE HISTORY STUDIES — PLANTS AND VEGETATION

Plants
Drug plants (Tehon 1951)
Filmy fern (Evers 1961)
Fungi (Burrill 1876, 1885)
Mosses, liverworts, and lichens (Wolf and Hall 1878)
Native and naturalized trees (Miller and Tehon 1929)
Native shrubs (Tehon 1942)
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Green stink bug (DeWitt and Godfrey 1972)
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Northern and western corn rootworm (Luckmann, Chiang, Ortman, and Nichols 1974)
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Pinewood nematode (Kogan, Appleby, and Bouseman 1982)
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Potato leafhopper (Gyrisco, Landman, York, Irwin, and Armbrust 1978)
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NATURAL HISTORY
SURVEY REPORTS

NOVEMBER 1985, NO. 251

nelt Fishing in Lake Michigan

Rainbow smelt (*Osmerus mordax*) supɔrt a lively, if brief, sport fishery along the linois shoreline each spring. On almost ıy Saturday evening in April, over 1,000 ıelt fishermen may crowd Montrose Harɔr and the immediate vicinity, while ıother 5,000 may use other sites along .e shoreline of Lake and Cook counties. [ost fishermen use gill nets — curtains of ɛtting designed to entangle the gill covers the small silvery fish as they swim along e shore seeking places to spawn.

Smelt are anadromous. The adults of ɛean-dwelling populations migrate for awning into freshwater tributaries along ɔrthern coastlines of North America, Euɔpe, and Asia. In Lake Michigan, smelt e vulnerable to shore fishermen in spring they swim into the tributary streams or allow areas to spawn. In Illinois, where ibutary streams are largely nonexistent ıd sheltered shallows are rare, the fate of gs is unknown. In other states bordering Lake Michigan, mature smelt go upstream at night, deposit their eggs, and retreat downstream the following morning. Fertile eggs hatch in 10-30 days and the fry drift downstream into the lake.

During the spawning peak, anglers may catch hundreds of fish each night, averaging over 50 smelt per net per hour. One party of five fishermen this spring landed over 1,000 smelt in approximately 2 hours on a Sunday night. However, the catch is unpredictable; the following Saturday, the catch rate was less than one fish per net per hour for all fishermen interviewed.

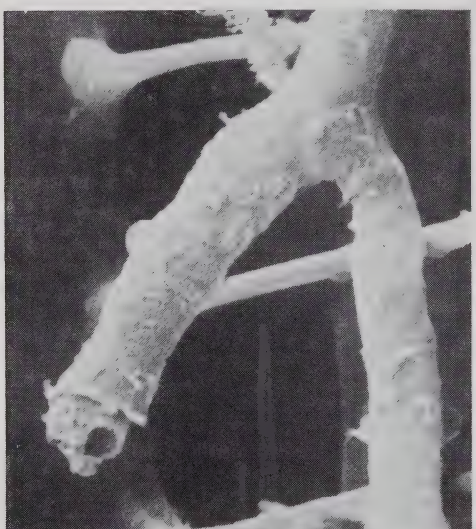
During the spawning run of 1985, William H. Horns and his assistants in the Aquatic Biology Section, with support from the Illinois Department of Conservation, conducted a creel of the smelt fishery. Fishing activity was assessed on 10 nights and 749 smelt fishermen were interviewed to determine the economic importance of the fishery. Each fisherman was asked how much he or she spent on food, gear, and

The rainbow smelt is usually a green-gray color with a silvery bottom (Original drawing by Craig Ronto).

transportation for the present trip. The average reported expenditure was $6.00. It was estimated from the nightly head counts that Illinois residents made 70,000 trips to Lake Michigan to fish for smelt, for an estimated total seasonal expenditure of $420,000.

Smelt were introduced inadvertently into Lake Michigan sometime between 1912 and 1923 and the population has fluctuated widely since then. The seed stock for Lake Michigan smelt probably was derived from the freshwater population native to Green Lake, Maine. The smelt that colonized Lake Michigan migrated from Crystal Lake, Michigan, where smelt were stocked in 1912 as forage for the introduced Atlantic salmon. The first smelt found in Lake Michigan was captured in 1923. By 1936, smelt could be found throughout the lake. The commercial harvest of smelt has varied widely in Lake Michigan, reaching a peak of 9.1 million pounds in 1958. In Illinois today the harvest of smelt by commercial fishermen is negligible.

Smelt have often been blamed for the decline of lake herring in Lake Michigan. Although smelt will eat lake herring fry and the life histories and spatial distributions of the two species would permit predation, the evidence against smelt is only



Scanning electron microscope photo of hyphae of a canker fungus in xylem vessels of healthy white birch, showing a hole in the cell wall of a burst hyphal tip (Photo by J. M. McPartland).

circumstantial and may be confused other factors, such as human exploitati and rapid expansion of alewife populatio several years ago. Dramatic fluctuations other Lake Michigan fish populations i cluding sea lampreys, lake trout, yello perch, and emerald shiners, have also c curred in this century.

Smelt may be assuming a position greater importance in the diet of salmoni in southern Lake Michigan. For ma years, alewives have comprised the bulk the diets of chinook salmon, coho salmo and lake trout. However, with the rece declines in alewife populations, smelt a being consumed at higher rates and m become an important food for salmon a trout populations in Lake Michigan.

Enzymes Versus Fungi?

Fungi that cause plant diseases co monly enter resistant and susceptible h plants with equal frequency, but are u able to attack and damage resistant hos However, even resistant plants may b come susceptible to fungal attack if th are weakened by environmental stress Many of the stem cankers and root rots trees and shrubs appear following droug periods or after plants are subjected freezing stresses during the winter.

The mechanisms involved in disaster sistance have been studied intensively ov many years, yet we understand little abo how these mechanisms operate. In m cases, resistance is an active metabolic sponse of the plant to infection. So plants produce compounds called phy alexins, which inhibit fungal growth, wh others produce enzymes or toxic co pounds that kill fungi. Nearly all of o knowledge on disease resistance mec anisms comes from research on crop plar How trees and shrubs resist attack pathogens has not received much attenti by researchers.

In a recent study on the influence of e vironmental stresses on stem canker d eases of woody plants, Survey plant path ogists D. F. Schoeneweiss and J. M. M Partland used a scanning electron mic scope (SEM) to examine the morpholo of canker fungi in healthy and droug stressed stems of white birch. At this

Orconectes stannardi, one of the two species of crayfish endemic to Illinois, occurs only in the Little Wabash River system (Photo by Lawrence Page).

tremely high magnification, the SEM revealed interesting surface structures of fungal hyphae. A high percentage of the hyphal tips, which are the growing points of fungal hyphae, were swollen and burst in healthy stem tissue, while those in stressed stems appeared normal. A closer examination revealed distinct holes in the cell walls of burst hyphal tips, indicating possible enzyme degradation of the cell walls.

Enzymes that lyse or degrade cell walls of fungi are known to be present in forest trees and it has been hypothesized that these enzymes serve a disease-resistant mechanism against fungal attack. Results of research at the Survey support this hypothesis. When and how these enzymes are produced and the effect of environmental stresses on these processes are questions that will require additional research to answer.

The Crayfishes and Shrimps (Decapoda) of Illinois

The first article in the first volume of the *Bulletin* of the Illinois Museum of Natural History (which later became the Illinois Natural History Survey) was an annotated list of the Crustacea of Illinois. It was written by Stephen A. Forbes, the first Chief of the Survey, and noted the presence in Illinois of nine species of decapods (crayfishes and shrimps). Little research on the systematics and distribution of these organisms was published subsequently to that early report, although two unpublished theses on the ecology and distribution of crayfishes were completed at the University of Illinois (in 1912 and 1955).

The recently published "The Crayfishes and Shrimps (Decapods) of Illinois" (Illinois Natural History Survey *Bulletin* 33 (4):335-448) was based on collections made at 1,294 localities in Illinois between 1972 and 1982, and raises to 23 the number of decapod species known in the state. Although Illinois decapods constitute a group of only 23 species, they often are present in large populations, are among our largest aquatic invertebrates, and exert an important influence on the ecology of Illinois streams and lakes.

The greatest diversity of crayfishes and shrimps in Illinois occurs in the extreme southern part of the state. Seventeen of the 23 species in Illinois can be found in the Shawnee Hills and on the Coastal Plain; 10 species are restricted to this area. Two crayfishes, *Orconectes illinoiensis* and *O. stannardi,* occur only in Illinois.

Two species known historically in Illinois appear now to be extirpated. One of them, the crayfish *Cambacus robustus,* may have disappeared naturally rather than because of man-induced changes in the environment. Our earliest records indicate that *C. robustuswar* is relict in Illinois, presumably having been reduced from a more widespread distribution to small areas near Quincy (found in 1885) and Decatur (1912). Elsewhere in the U.S. and Canada, it inhabits cool to cold streams. It apparently was reduced in warm postglacial Illinois to small populations that subsequently were unable to perpetuate themselves. The other species, the shrimp *Macrobrachium ohione,* probably disappeared because of the extensive modification and degradation of Illinois' largest rivers. Four other species appear now to be in grave

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danger of extirpation and have been recommended for inclusion on Illinois' List of Endangered and Threatened Species.

The most recent addition to the Illinois fauna is a crayfish (*Orconectes rusticus*) native to southern Ohio and northern Kentucky but now distributed widely outside its native range through its extensive use as fish bait. It has become established in several streams in northeastern Illinois and near Peoria. Once introduced, this species usually displaces native species and expands its range, apparently because it is a large and aggressive species able to survive in disturbed habitats. Because it displace native species and is a vigorous consume of aquatic vegetation, its continued use a bait in Illinois should be discouraged.

"The Crayfishes and Shrimps (Deca poda) of Illinois," by Survey zoologist I M. Page, describes the appearance of eac species, discusses its distribution, bot within and outside Illinois, describes char acteristics of its habitat, its diet and its re productive cycle. This publication, whic may be obtained by writing to the Chie INHS, is the latest in the Survey's series c reports on the biota of Illinois.

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NATURAL HISTORY
SURVEY REPORTS

DECEMBER 1985, NO. 252

A Directory of Systematists and Ecologists in Illinois

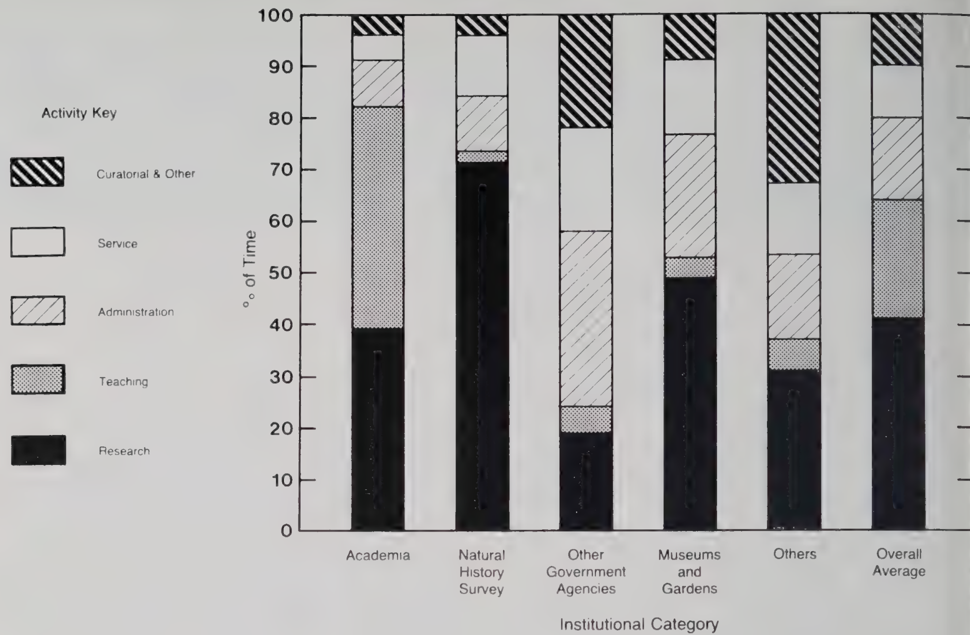
A data base of systematists and ecologists that live and/or work in Illinois has been compiled by scientists of the Illinois Natural History Survey. *A Directory of Illinois Systematists and Ecologists* will be published early in 1986 with partial financial support from the Illinois Department of Transportation, Bureau of Location and Environment. The ongoing project is under the direction of Kenneth R. Robertson, with Philip J. Burton and Bill N. McKnight (all of the Survey's Section of Botany and Plant Pathology) doing the data computerization and summarization.

Illinois is fortunate in having a large number of biological systematists and ecologists affiliated with colleges, universities, museums, botanical and zoological gardens, private companies, and governmental agencies. While a number of professional societies have membership lists, there has been no single source that gives addresses, telephone numbers, and areas of expertise for this group of scientists in Illinois.

Systematists study the classification and evolutionary relationships of organisms, while ecologists study the interactions of organisms with their biotic and abiotic environments. Systematists and ecologists generally share common interests in the evolutionary history and dynamics of organisms and in the conservation of their existing populations. In addition, both groups of scientists include field biologists well versed in the taxonomic identification of organisms and the estimation of population sizes and habitat requirements. Because of increased environmental awareness, the practical skills of this group of researchers are in high demand for use in environmental impact statements, natural area inventory and management, agricultural and forestry management, and for public education.

Information for the directory was obtained from a questionnaire that was mailed to more than 800 persons in January 1984. All responses (435) received by December 1984 have been entered into computer files. The directory includes a summary of responses to all questions and is organized alphabetically by name. Separate indices have been prepared for broad groups of organisms studied, systematic techniques used, and ecological interests, as well as for specific geographical place-names and key words denoting areas of taxonomic and ecological expertise. The indexing system allows complete cross tabulation of chosen response categories and/or key words. Both the data base and the published directory will be updated periodically to keep them current. Working scientists should find the directory handy as an address book of colleagues, and others are expected to use it as a resource book to locate systematists and ecologists with specific areas of expertise.

Many interesting features of this segment of the biological research community became apparent while summarizing the information supplied by respondents. For example, almost all respondents (96.5%) listed Illinois as their address: within the state, Urbana-Champaign (with 111 respondents) and Chicago (79 respondents) have the largest number of respondents. Half of the respondents (49.1%) are affiliated with colleges and universities, while



A Directory of Illinois Systematists and Ecologists includes summaries of the time commitments (showr he.e by affiliation) and research interests of this group of scientists in Illinois (graph drawn by Phil Burtor and Bill McKnight).

the remainder are approximately evenly distributed among the Illinois Natural History Survey (14.2%), other state, federal and municipal agencies (14.0%), museums, arboreta, parks, gardens, and zoos (11.6%), and others (11.1%).

Differences in time-allocation among respondents were some of the most interesting results summarized from the biographical data presented here in a graph by two of the authors (see above).

A total of 386 respondents (89.8%) reported having a bachelor's degree, 323 (75.1%) have or are working on a master's degree, and 290 respondents (67.4%) have or are working on a doctoral degree. These figures are indicative of the long period of training and post-graduate work generally required to be a practicing systematist or ecologist. Of the 1,013 college degrees reported by respondents, a total of 345 (34.1%) were awarded by Illinois colleges or universities. The average year for a bachelor's degree was 1965, 1969 for a master's degree, and 1971 for a doctorate. On the average, respondents have been with their organizations since 1973, indicating an experienced contingent of resident biologists.

All individuals included in the directo will receive a copy, while other intereste persons may obtain single copies of th *Special Publication 3* free of charge fro the Office of the Chief, Illinois Natur History Survey (address at the end of th publication).

Sediment Contamination in Waukegan Harbor

Waukegan, situated in northeastern Il nois 36 miles north of Chicago and 8 mil south of the Wisconsin border, is one of t state's primary Lake Michigan ports. Wa kegan Harbor handles commercial shi ping, serves as a base for chartered fishi boat excursions, and is a major center f pleasure craft. Since 1975 the harbor h been identified as a site of serious co tamination by polychlorinated biphen (PCB's).

PCB's are a family of synthetic orga compounds with high heat capacity, l electrical conductivity, and strong resistan to oxidation and vaporization. They we used as insulating material for electri transformers and capacitors, and as a he absorbing medium in the cooling phase

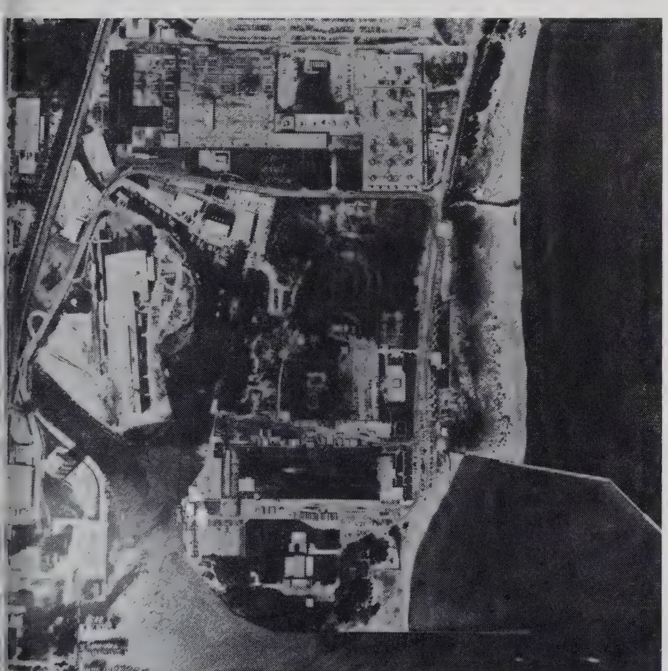
metal casting processes. PCB's are very stable molecules, tending to persist for many years if released into the environment. While not very soluble in water, they are highly soluble in lipids and oils, permitting them to accumulate in fatty tissues. Tissue concentrations of PCB's are magnified as they move up the food chain, and laboratory studies have linked them to liver cancer in rats, infertility in rhesus monkeys, and stomach nodules in dogs.

In 1979 the United States Environmental Protection Agency (USEPA) expressed concern about human health risks from consuming fish caught near Waukegan. Preliminary studies showed high PCB concentration in sediments at many locations in Waukegan Harbor and in 1981 a clean-up program was proposed. Since that time a lengthy series of litigations between USEPA and Outboard Marine Corporation (OMC) has forestalled any remedial action. The situation is complicated by the fact that accumulating sediments have reduced water depths in some locations to the point where navigation is limited. The extensive dredging operations required to correct this would create further environmental problems.

A team of State Survey scientists has been formed recently to answer some questions concerning the Waukegan Harbor PCB problem. Michael Henebry and Philippe Ross, both in the Aquatic Biology Section of the Natural History Survey, and J. Bruno Risatti, in the Geochemistry Section of the State Geological Survey, have received a grant from the State Department of Energy and Natural Resources (DENR), through the Hazardous Waste Research and Information Center (HWRIC), for the "Assessment of Ecotoxicological Hazard of Waukegan Harbor Sediments."

One of their objectives is a thorough sampling and mapping of the area to determine the extent of the contamination problem. PCB concentrations in sediments, benthic organisms, and fish will be measured. These results will be especially useful because many data files from preliminary studies have been legally sequestered pending the outcome of the judicial process.

Using a process known as *elutriation,* the research team will simulate the effect of dredging operations on the release of PCB's and other contaminants from the sediments into the water column. A series of toxicological tests will help estimate risks to



An aerial view of the Waukegan harbor. Lake Michigan is to the east (photo courtesy D. Caplice, USEPA).

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aquatic life. These tests will measure mortality and growth rates for zooplankton and nematodes, sublethal effects on metabolic processes of bacteria and algae, and mutagenesis in bacteria.

Another series of tests will look at the effects of exposure to Waukegan Harbor water on aquatic protozoan communities. Artificial substrates made of polyurethane foam blocks will be used to collect protozoans at a relatively "clean" site in Lake Michigan. Some of these colonized substrates will then be transferred to sites in the harbor, and the number of different species and their population densities will be measured over different time intervals and compared with substrates remaining at the clean site.

Recent work on PCB's in sediments suggests that anaerobic bacteria may declorinate PCB's and utilize these compounds as a source of materials for growth. This process, which could help alleviate the con[tamination] problem in Waukegan Harbo[r] is being studied in two ways. First, inta[ct] sediment cores are taken back to the labor[a]tory where PCB breakdown rates fro[m] specific sites are determined by analyzi[ng] PCB concentrations in sediments that ha[ve] been incubated at different temperatur[es] for various periods of time. Overall ba[c]terial activity in the sediments containi[ng] PCB's will be correlated with methane pr[o]duction. In this way the possibilities f[or] natural breakdown can be estimated. Se[c]ond, the feasibility of introducing oth[er] bacterial species to accelerate the brea[k]down process will be assessed. If sedimen[ts] in Waukegan Harbor and other contam[i]nated sites could be "seeded" with PC[B-] degrading organisms (which would th[en] die off when no more PCB's remained) this would be an exciting development [in] environmental waste management.

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NATURAL HISTORY SURVEY REPORTS

JANUARY 1986, NO. 253

Mushrooms and Spring Fever

The sunny days of spring herald the appearance of the spring mushrooms and, of course, bring out the mushroom hunters. Spring is when the delicious morel is found.

The morel is easily identifiable and is recognized by a hollow stem capped with a hollow spore-producing tissue that has ridges and deep, rounded or angular pits which give the cap the appearance of a sponge. This morel, or sponge mushroom, is not a mushroom in the sense that it belongs to the class Ascomycota. In comparison, the commercial mushroom has gills on the underside of a cap and belongs to the class Basidiomycota.

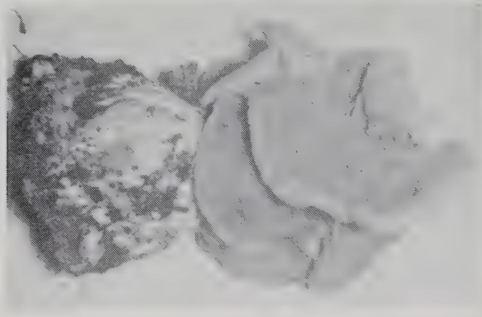
A day of searching woodlands, hillsides, and ravines in the cool spring air, followed by a meal of this delicacy simmered slowly in butter, will surely cause most mushroom hunters to feel the contented lassitude called spring fever. However, the fatigue may be persistent for several days, and the abdomen may become swollen and the stomach painful if the false morel is eaten, according to Jean D. Schoknecht, medical mycologist, Department of Life Sciences, Indiana State University, who is also an affiliate in Botany and Plant Pathology at the Survey.

Caution should be exercised so that the similar *Gyromitra esculenta* is not eaten as well. This false morel is often collected along with the edible morel, a species of the genus *Morchella,* in spring in Illinois. Its globular cap is not like a sponge as is its close relative the morel, but is irregularly lobed and can be 5 to 8 and even 10 cm in diameter and 6 to 32 cm tall. Its cap does not have regular ribs and deep pits as the true morel, but is irregularly folded or convoluted like a brain or crumpled blanket. It is variable in color, from tan, yellowish-brown, red-brown, or even darker. The stem is hollow, often furrowed and white to tan in color.

The false morel should be regarded as dangerous. Yes, many Illinoisans collect this false morel and will attest that it is edible and very tasty. Luck, however, runs out for some, as 2 to 4 percent of all mushroom fatalities result from eating these false morels.

Gyromitra esculenta is known to contain monomethylhydrazine (N-methyl-N-formalhydrazine) which has been called helvellic acid or gyromitrin. Gyromitrin is a very strong hemolytic compound which rapidly causes rupture of red blood cells, causing hemoglobinuria and also hemolytic jaundice from effects on the liver. Poisonings with *G. esculenta* begin to show 2 to 12 hours after eating the mushroom. The symptoms are abdominal pains, nausea, vomiting, and bloody diarrhea, cramps, swelling of the abdomen, weakness, lassitude, and headache. The symptoms may be mild; however, if the condition is severe these develop into swelling of the liver, jaundice, convulsion, coma, and even death. The liver and kidney are most damaged.

Recipes abound for making the "mushroom" safe. For example, boiling first and throwing the liquid away does remove some gyromitrin from the mushroom, but gyromitrin can be carried in the steam, absorbed through the nose, and cause illness. Therefore, it is dangerous to the cook to boil these. Moreover, enough gyromitrin can be left in the fungus to cause illness.



Top: The poisonous mushroom, *Gyromitra esculenta*, or the false morel.

Right: The true morel, *Morchella* sp., which mushroom hunters seek in the spring (photos by Jean Schoknecht).

As this is reportedly a tasty mushroom, many devoted mycophagists have sought to explain why it is sometimes more poisonous than at other times. Many cases of death from eating the false morel occurred to individuals who had eaten them before. Some of the poisonings described are interesting because not all of the persons who ate the mushroom dish were taken ill. In a family, some members may suffer no effects, some become ill, and some die from the same dish. This may be explained by differing quantities ingested or perhaps individual susceptibility to the poison.

There is obviously much individual difference in the amount of gyromitrin contained by an individual mushroom and it may vary according to region, weather, or other conditions, and is thus dependent on still insufficiently investigated factors. There is currently *no* evidence that any visible physical factor such as age, cap size or color, nor that any growth factor is related to production of gyromitrin. In other words, there is no way to recognize a very poisonous specimen. Although some mushroom texts recommend that *Gyromitra* should never be eaten raw, there is no treatment that renders them safe.

Pine Squirrels in Deciduous Forests

The pine or red squirrel is common throughout the coniferous forests of North America and is known for its strong territorial behavior. Adult red squirrels defend their home ranges by calling at and chasing after intruders. This behavior has evolved to protect the food supply of th individual squirrel and controls populatio size by limiting the number of squirrels th can live in a particular area.

Red squirrels occurred in Illinois aroun the turn of the century but have been a sent from the state for about 60 years b fore their reappearance in the mid-1970 In an effort to determine the status of th red squirrel in Illinois, Survey scientist W. Brown has undertaken a study of th red squirrel in deciduous habitats in Il nois. Apparently red squirrels have n been reintroduced into pine forests in Il nois. The range of the red squirrel in Il nois seems to be concentrated along t Kankakee and Iroquois rivers in easte Illinois. Populations are also known fro the Beaver Creek area, the Iroquois Coun Conservation Area near Indiana, a Thorncreek Woods in Will County. It a pears that red squirrels are expanding th range in Illinois. The origins of these po ulations appear to be a combination of r squirrels from Indiana expanding th range down the Kankakee River syste into Illinois and the introduction of r squirrels from Minnesota in the 1960's.

Live-trapping and radio-tracking da

The pine or red squirrel as found in localities having black walnuts in Illinois (photo credit: Museum of Zoology, University of California, Berkeley).

from red squirrels living in deciduous habitats indicated that, in contrast to squirrels in coniferous habitats, red squirrels in Illinois are not territorial. This difference in behavior is probably because food supplies in deciduous forests are difficult to defend. Furthermore, red squirrels have little effect on fox squirrels living in the same areas in deciduous habitats in Illinois. Although gray squirrels are common in many areas of Illinois, they are not found in the same regions as red squirrels. Both gray and fox squirrels have been reported from areas where red squirrels were common, but reports of interactions were rare. Thus, it is not known if red squirrels compete with fox and gray squirrels in coniferous habitats.

Observations of food habits and vegetational analysis of red squirrel habitats indicated that black walnuts were important to red squirrels in deciduous forests in Illinois. At present red squirrels occur only in habitats with black walnuts in Illinois, but it is not known if black walnuts are an essential component of the habitat. Neither forest quality nor tree density seemed strongly related to red squirrel populations.

Conservation Tillage and Pesticides

Over the last decade, farmers have adopted wholeheartedly conservation tillage practices to control soil erosion. There are many kinds of conservation tillage systems, but all leave crop residue on the soil surface to decrease erosion of soil by strong winds and torrential rain storms.

Coincident with the adoption of conservation tillage practices, farmers have been using more pesticides. The soil environment is substantially different in no-till than in conventional tillage. The properties most affected by lack of tillage, e.g., moisture, temperature, organic matter content, microbial communities, are those that influence the fate, behavior, and efficacy of soil-applied pesticides. Crop and environmental protection specialists are concerned about the performance and behavior of pesticides under no-till conditions. These concerns can be expressed as three questions:

1. Will pesticide use and application rates need to be increased under conservation tillage?
2. Will degradation rates and metabolic pathways be different enough to affect bioactivity of the pesticides?
3. Will leaching and runoff of pesticides be changed by leaving more crop residue on the soil surface?

To answer these questions, entomologists Allan Felsot, Kevin Steffey, and Eli Levine have been investigating the fate of soil insecticides and interactions with pests in cornfields managed with conventional and conservation tillage systems. Studies were conducted during the 1983-1985 growing seasons at the University of Illinois Cruz farm in Champaign and at the Northwestern Illinois Agricultural Research and Demonstration Center near Monmouth. At planting time soil insecticides were applied to cornfields that were prepared by molboard plowing (conventional tillage), disking or chiseling (reduced tillage), or left untilled (no tillage).

At various time intervals following planting, soil cores were collected to determine the degradation rate of the insecticide in the top 4 inches of soil. This segment of the soil profile around the corn roots is where most corn rootworm feeding would occur. Soil columns of 8 inches in length were also taken from the experimental field plots and sliced into 2-inch sections to measure the distribution of pesticide around the root zone and to determine if any chemical was moving deeper

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into the soil profile. Corn rootworm and black cutworm feeding damage and crop yields were measured. To estimate the size of rootworm populations and therefore the amount of stress from root pruning, adult beetles emerging from the soil were trapped and counted during July and August. Rootworm eggs laid in the soil were sampled in the number of eggs per acre estimated.

Felsot, Steffey, and Levine have concluded that insecticides can effectively control corn rootworms with current rates of application. Initial emergence of adult beetles was delayed about 1 week under no-till conditions, but peak emergence did not differ from conventional tillage. Black cutworm damage tended to be greatest in no-tillage plots. Corn yields tended to be lower in no-tillage systems without insecticides. However, yields were not significantly different when insecticides were applied.

The insecticide residues were confined mainly to the top 2 inches of the soil profile regardless of tillage system. This limited distribution of the insecticides might result in inadequate root protection, especially if rootworms are feeding at a depth of 3 to 4 inches and populations are ver large. This hypothesis may help explai why soil insecticides sometimes do not pro vide sufficient protection of the roots.

Felsot has been investigating also th influence of tillage systems on pesticid runoff in cooperative studies with Professc J. Kent Mitchell from the Agricultura Engineering Department at the Universit of Illinois. Preliminary results showed tha no-till is effective in reducing pesticide run off from sloping ground. Orienting the cro rows on the contour can significantly re duce washoff of the more water-solubl herbicides and insecticides in the movin water. This research will help farmers wit crop land in watershed regions to decid which field management practices they ca adopt to control movement of pesticide into nearby streams, ponds, and lakes.

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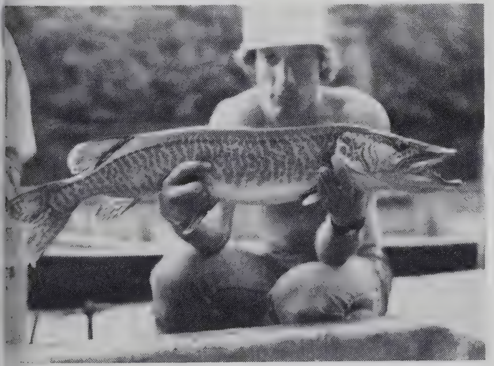
NATURAL HISTORY SURVEY REPORTS

FEBRUARY 1986, NO. 254

The Muskies in Ridge Lake

In an effort to improve the balance between predator and panfish populations and to add diversity to the creel in the form of trophy species, many state fisheries agencies have considered stocking members of the pike family into lakes and reservoirs. The tiger muskellunge, which is the hybrid of the muskellunge and northern pike, has a greater potential in this role than either parent species because it is better suited to artificial propagation and is more tolerant of high summer temperatures. However, the hybrid had not been adequately tested in impoundments where summer water temperatures are very warm and where the only fish species available as food are largemouth bass and bluegill. Consequently, Natural History Survey scientists Ted Storck and Dennis Newman conducted a study beginning in 1981 to measure the contribution of tiger muskellunge to the sport fishery in small bass-bluegill impoundments.



Doug Austen holds largest tiger muskellunge caught in Ridge Lake during the summer of 1985 (Photo by Barry Newman).

Ridge Lake, a 16-acre experimental fishing lake operated by the Survey and located in Fox Ridge State Park, Coles County, Illinois, served as the study site. The lake was stocked in the summer and autumn of 1981 with largemouth bass, bluegill, channel catfish and 150 fingerling tiger muskellunge. An additional 75 fingerling hybrids were stocked in 1982. A complete creel census, conducted on Ridge Lake in 1982-1985, measured the total catch and harvest of all four fish species present. The lake was drained at the conclusion of the 1985 fishing season to assess the full impact of the tiger muskellunge on the fish community.

Although tiger muskellunge are capable of reaching legal size (30 inches) in 2 years under optimum feeding conditions, few individuals stocked in Ridge Lake in 1981 and 1982 had reached this size in the fall of 1985. During the four fishing seasons, anglers harvested only four legal-size tiger muskellunge but caught and released 389 sublegal fish. Because most of these sublegal fish were larger than largemouth bass harvested during the same interval at Ridge Lake, the tiger muskellunge made an exciting contribution to the catch-and-release fishery.

Fortunately, only 15 percent of the sublegal fish caught died because of the hooking and handling experience. Most hooking deaths occurred in midsummer when water temperatures were warmest; however, mortality was minimized because relatively few tiger muskellunge were caught during midsummer.

Twenty-seven tiger muskellunge survived to the draining in October 1985 and only

five fish were longer than 30 inches. The largest survivor was 4 years old, 34 inches long, and weighed 8.8 pounds.

In addition to contributing to the creel, it was hoped that predation by the tiger muskellunge would help reduce the number of bluegills. If the tiger muskellunge were successful in this role, surviving bluegill should grow faster, resulting in improved population structure and greater potential harvest of large bluegill. Also, it was important that the tiger muskellunge not eat too many largemouth bass thus reducing that species' contribution to the creel. Although food habit data from Ridge Lake suggested that the tiger muskellunge ate mostly bluegill, the growth and population structure of bluegill remained poor. In contrast, the abundance, growth, and angler catch of largemouth bass were strong indicating that tiger muskellunge had not harmed that population.

Tiger muskellunge can make a useful contribution to the sport fishery of small, warmwater impoundments dominated by bass and bluegill. Although few tiger muskellunge will reach trophy size with bluegill as the principal forage, many will reach a larger size than that attained by largemouth bass at the same age. Based on the size structure of angler-caught tiger muskellunge at Ridge Lake, harvest can be increased substantially by reducing the minimum legal length limit by 2 inches. Unfortunately, the increase in harvest of legal tiger muskellunge would occur at the expense of the trophy and catch-and-release fishery. Tiger muskellunge are unlikely to control prey species in most impoundments.

Ridge Lake will be closed to fishing in 1986, but will reopen in 1987. The lake has been refilled and will be restocked in the spring and summer with largemouth bass, bluegill, black crappie, and channel catfish. Walleye and additional catfish will be stocked in 1987, 1988, and 1989. Fishing will not be permitted until 1987 so that fish populations will have time to attain densities necessary for good fishing.

"Acid Rain"

Currently the major air pollutants are ozone, sulfur dioxide, nitrous oxides (NO_x), and acidic rain. Of these, acidi rain probably is the least understood as t its effects on plant growth and crop yiel Wet deposition with acidity below pH 5. is generally referred to as "acid rain." Th wet deposition can be fog, mist, or precip tation.

In Illinois, the two most abundant acid components in precipitation are sulfat and nitrates. In central Illinois, 80 percen of all rains range between pH 3.85 an 4.65. The lowest reported pH in this regio has been 3.51.

Much national attention has been give to the potential for deleterious effects o acidic precipitation on the aquatic life o certain sensitive freshwater lakes in th Adirondack Mountains of New Yor However, no general consensus has bee reached on either the direct or indirect e fects of acidic rain on terrestrial plant The reasons for uncertainty are numerou but soil type, plant competition, and th genetic make-up of the plant are facto that can influence plant responses. Su furous components of acidic rain can a as a plant nutrient and stimulate plan vigor, further complicating interpretatio

From rain simulation studies, the thresh old pH for the occurrence of visible plan injury is between 3.0 and 3.6. Much les however, is known about chronic exposu of plants to more naturally occurring rai acidities. To look at this question, plan physiologist Claus Grunwald and his asso ciates exposed soybean plants under con trolled conditions to 40 rains of centr Illinois ion composition over a 120-da period. Each rain event of 0.5 lasted for hour. They examined three acidity level pH 3.5, 4.5, and 5.5. The rain of pH 5 can be considered neutral rain, but an ad ditional no-rain control (plants we watered without wetting the leaves) wa included.

Soybean plants that received pH 3.5 an 5.5 rains showed no difference in plan growth and also did not differ from plan that did not receive any rain. Howeve soybeans that were exposed to pH 4.5 rai showed a slight, but significantly greate growth rate. Nutritional effects due to th rains' nitrogenous or sulfurous componen were ruled out.

The median pH of central Illinois rains is 4.3, thus, growth stimulation may occur under natural rain.

Other aspects that were studied were changes in soil pH and root development. Since Illinois soils are highly buffered, the various acidic simulated rains had essentially no effect on soil pH. Soybeans grown under pH 4.5 rain had the most vigorous roots and showed the highest rate of nitrogen fixation. The higher rate of nitrogen fixation is most likely a result of stimulated photosynthesis.

The working hypothesis is that apparently the acidity of the rain influences the behavior of the leaf stomata (pores) and alters the gas exchange of the leaf, thereby impacts on photosynthesis and plant growth. The reported negative effects of acidic rain on plant vigor may be the result of an interaction of various environmental factors rather than a response to a single component.

Tillage Practices Affect Stalk Borer

The stalk borer can be a serious pest of seedling corn. Female moths deposit their eggs primarily on grassy vegetation in fence rows, contour strips, waterways, or weedy fields during the late summer and early fall. The winter is spent in the egg stage. After the eggs hatch the following spring, the larvae begin feeding on grasses but move to larger plants as they outgrow their original hosts or when these original hosts die from herbicides applied at planting. Corn may serve as a larger or alternate host if planted in or near infested vegetation.

The recent increased use of conservation tillage practices by Midwest corn growers has led to a greater incidence of stalk borer problems. Although it is known that fields with grassy vegetation are preferred oviposition sites, it is not known what impact fall and spring tillage and the presence of green weeds at egg hatch in the spring have on the survival of stalk borers. Survey entomologist Eli Levine designed experiments to test the effect of three tillage practices (conventional till, reduced till, and no-till) at two levels of weed control (weed growth in spring and no weed growth in spring) on damage to corn seedlings by stalk borer larvae (injury to corn seedlings was used as a relative measure of cornstalk survival). Knowing the impact of tillage and weed populations on the survival of stalk borers will have important implications for the management of this pest.

Each experiment, the first conducted in 1983-1984 and the second a replication of the first in 1984-1985, was arranged in a split-plot design with six replications at a Champaign field. Tillages were arranged as main plots and weed control levels as subplots. In the 1983-1984 experiment, egg masses were taped to flagged weeds (principally fall panicum and giant foxtail, one egg mass per subplot) in late October 1983 (after harvest but before tillage operations took place). Winter wheat was sowed to supplement natural weed growth in the plots with no weed control. The conventionally tilled plots were moldboard plowed and the reduced-tilled plots were chisel plowed in mid-November; on May 14, 1984 these plots were disked in preparation for planting. The entire field was treated with a corn herbicide and planted into corn that same day. The number of corn seedlings damaged in an area measuring 0.005 acre around the plant where each egg mass was originally placed was recorded from plant emergence through the seven-leaf stage on June 19.

Tillage (both conventional and reduced) significantly decreased stalk borer infestations when compared to the no-

Portion of tillage/weed growth field experiment in early May 1985, just prior to planting. Central portion of the figure shows a no-till plot. Subplot with the high level of weed control is on the right side of this plot (Photo by Eli Levine).

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tillage treatment. For both reduced tillage and no-tillage treatments, the absence of weed growth in spring tended to decrease resulting infestations of larvae; the difference was not significant at the 5 percent level, however. Eggs were estimated to have begun hatching on May 7, and 50 percent had hatched by May 11 (based on hatch data of eggs placed in an adjacent weather shelter). Thirteen days elapsed between 50 percent egg hatch and the appearance of one-leaf stage corn seedlings.

In the 1984-1985 experiment, two egg masses were taped at the soil surface to a stake partially inserted into the soil of each subplot in late October 1984. Winter wheat was again sowed to supplement natural weed growth in the subplots with no weed control. The conventionally tilled plots were moldboard plowed and the reduced-tilled plots were chisel plowed in mid-November 1984 and disked on April 18, 1985. In the subplots with the high level of weed control, existing plant growth was controlled with the burn down herbicide paraquat on April 25. The conventionally tilled and reduced-tilled plots were disked again on May 9 and the entire field treatec with a corn herbicide and planted intc corn that same day. The number of corr seedlings damaged in an area measurin 0.005 acre around the spot each egg mas was originally placed was recorded fron plant emergence through the seven-lea stage on June 18.

As in the first experiment, tillage (botl conventional and reduced) significantl decreased stalk borer infestations wher compared to the no-tillage treatment. Fo the no-tillage treatment, the absence o weed growth in spring significantly de creased resulting infestations of larvae Eggs were estimated to have begun hatch ing on April 22, and 50 percent hac hatched by the next day. Twenty-seve days elapsed between 50 percent egg hatcl and the appearance of one-leaf stage cor seedlings.

The results of these studies suggest tha no-tillage planting practices favor the sur vival of stalk borers and that even withou the presence of green vegetation at eg hatch, stalk borer larvae can survive a shor period of time until the crop emerges.

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NATURAL HISTORY
SURVEY REPORTS

MARCH 1986, NO. 255

Low-Temperature Cracks in Trees

Did you ever try to make a coffee table out of a cross-section cut from a tree trunk? Unless you are very knowledgeable or extremely lucky, after 1 to 3 years, a wedge-shaped crack will develop from the margin to the center. This occurs because shrinkage of wood as it drys in the three dimensions (longitudinal, radial, and tangential) is unequal. Wood does not shrink until the moisture content of the cell walls has been reduced below the fiber saturation point. From green to oven dry, wood shrinks longitudinally 0.1 to 0.3 percent, radially 2 to 3 percent, and tangentially 3 to 6 percent. This unequal (anisothropic) dimensional shrinkage also has an important effect on the distortion of flat, square, and round boards of lumber as they dry. The orientation of the growth rings determines the ultimate shape.

This unequal shrinkage occurs with freeze-drying just as in the normal drying. There is essentially no shrinkage of a tree stem at temperatures down to 32° F. At temperatures below the freezing point, the differential shrinkage is significant and caused by internal drying. Moisture migrates out of the cell walls of the wood to freeze in the empty cell spaces. The cellular components pull closer together; in effect both the cell walls and the wood shrinks. Freeze cracks result when the wood ruptures due to extensive tension stress in the tangential direction of the wood's annual rings. The cracks are commonly known as frost cracks.

Freeze cracks in the trunk of trees are vertical wounds on a radial plane. They are most evident in winter at temperatures below 15° F. when the wound opens, producing a long, deep slit in the trunk. The wound frequently reaches from near the ground to a height of 6 to 15 feet. The depth of the wound is constant, continuing from the center of the tree out through the wood and bark. The height of the wound

This London plane tree has a series of three cracks on one side of the tree. Approximately 60 percent of the cracks in this group of trees studied had freeze cracks on the southeast, south, or southwest side; the remaining 40 percent were facing the west, northwest, north, northeast, or east. Apparently the wood in the bole of the tree that is directly heated by sunlight is somewhat weaker than wood not directly exposed (photo by former Survey photographer, Wilmer Zehr).

on individual trees varies depending upon tree history of disease, previous winter temperatures, age, and other cracks.

Once a freeze crack occurs on a tree, it is likely to appear annually. It requires much less stress to open an old wound than to form a new one. To date, no one can fully explain why some tree species and not others, or some individuals with a species and not others, are especially susceptible to frost cracks. The radial weakness is most likely due to previous injuries or diseases. In Illinois, the tree species observed to be most susceptible to frost cracks are London plane, oak, maple, horsechestnut, linden, and willow.

Drs. E. B. Himelick and Dan Neely have collected data from London plane trees on the University of Illinois campus. They have confirmed that existing cracks gape as the stem temperature drops below 32° F. and close as the stem temperatures return to 32° F.

The stem circumference at a marked point on each of 25 trees on the campus was measured for 3 years either at 8:00 a.m. or at 2-hour intervals throughout the day when the ambient air temperature was below freezing. The cross-sectional area of the tree at that point was calculated. At 0° F. the shrinkage of the trunk in trees without freeze cracks was 2.6 percent. The trunk shrinkage in trees with freeze cracks was 2.01 percent.

Stem wood temperatures at varying depths were measured with themocouples inserted into the trunks in the four cardinal directions. At the 3-inch depth wood temperatures varied directly with ambient air temperature with very little lag time. The wood temperatures in the cardinal directions were not significantly different. Even at the 9-inch depth the wood temperature was almost the same as the air temperature.

The width of the freeze crack varied directly with the wood temperature. The lower the wood temperature at 8:00 a.m., the wider the crack. As wood temperature increased during the day, the width of the crack decreased. These data refute the common textbook explanation that cracks form when sudden and pronounced drops in temperature cause the outer wood of the
stem to contract while the inner wood re
mains insulated and contracts less.

Freeze cracks are a serious problem fo
the forester. The resulting log is defectiv
and cannot be used for lumber. Freez
cracks are less serious on the amenity tree
They provide an opening for disease or
ganisms and insect pests. Fortunately, th
wound is open only during the winter whe
the probability of infection or infestatio
is lowest. Attempts to bolt or staple th
wounds to prevent winter opening hav
been unsuccessful. Maintenance of stress
free trees through proper pruning, fertiliz
ing, watering, and insect and disease con
trol is the treatment most likely to reduc
the risk of freeze cracks.

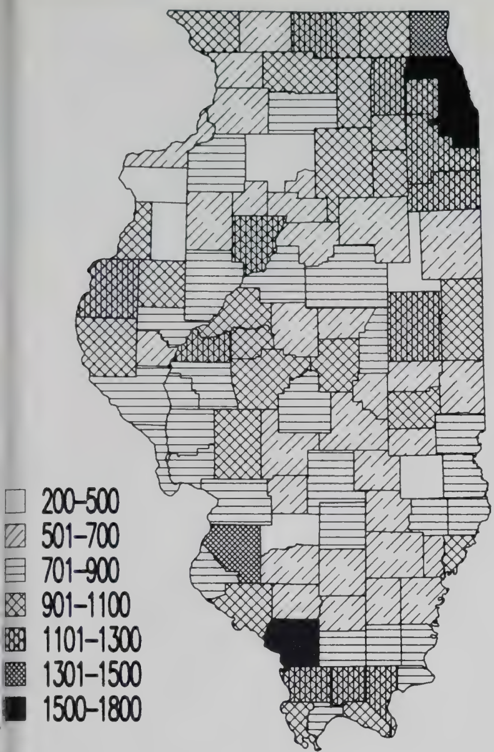
Illinois Flora Data Base

Illinois has a wide diversity of plan
communities within its borders because o
its geography, climate, and geologic history
The many kinds of plants present in th
state occur because of the mixing of specie
from western prairies, Ozarkian compo
nents, southern coastal plain environments
driftless northwestern regions, Appalachia
flora, eastern deciduous forests, norther
boreal components, and from cosmopolita
exotic sources. This multitude of source
from which species have invaded and th
diversity of habitats north to south resul
in more than 3,100 plant species presen
in the state, more than many other mid
western states.

Researchers Louis Iverson and Jea
Karnes in the Botany and Plant Patholog
Section are attempting to compile informa
tion on these species into a computerize
data base called the Illinois Plant Informa
tion Network (ILPIN). This data base ha
over one hundred variables on each specie
including the major categories of tax
onomy, distribution, population dynamic
ecologic relations, biologic features, hu
man, wildlife/livestock, and reclamatio
attributes of the species.

Figure 1 is a map of the number of spe
cies recorded for each county. These num
bers of species are related to the intensit
of field collections to the diversity of habi
tats. The highest diversities occur in th
south and northeast parts of Illinois.

Besides such distributional informatio



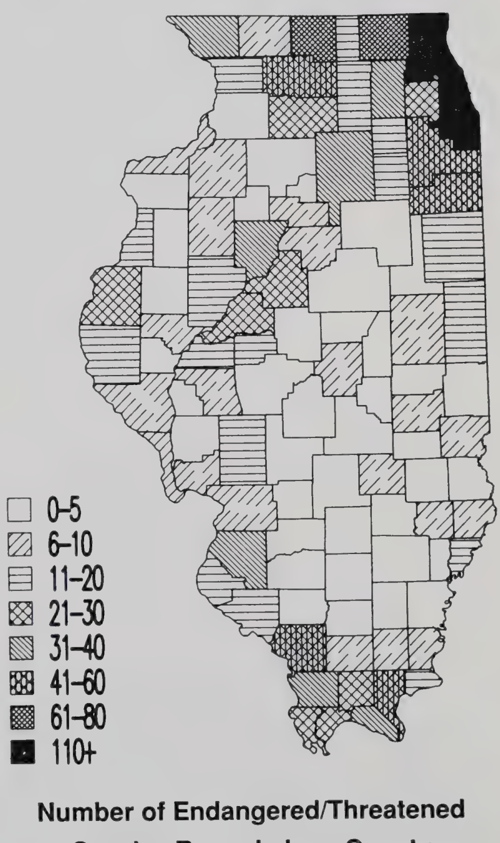
Number of Species Recorded per County

the data base can be asked any number of questions. For example, if one were planning a field trip to mesic forest in Jackson County in May, one could get a printout of all the herbaceous species that should be flowering with red blossoms and are pollinated by butterflies. Or, one could get a listing (scientific and common names) of all the plants that are native on hill prairies which are nitrogen-fixing legumes. Or, it would be possible to obtain a listing of suitable plant species for planting on saline soils which are good for wildlife food and cover.

Special emphasis has been placed on accumulating information on Illinois 364 endangered and threatened plants. The known distribution of threatened and endangered plants across the state is correlated with the general distribution of plants (Fig. 2), with Cook (135 species) and Lake (116) counties having the most threatened and endangered species. McHenry (68), Winnebago (61), and Pope (56) counties have large numbers of known threatened and endangered species also. Many counties, especially in the heavily cultivated regions, have less than five known threatened and endangered species. Regardless of location in the state, it is imperative that we conserve remaining natural habitat in the state such that these sources of biotic diversity are not lost.

Approximately 28 percent of the state's flora is not native to our state, but rather introduced from outside its borders. Most weeds in agricultural and disturbed ecosystems were introduced accidentally or intentionally, especially from Eurasia. These exotic species are frequently a menace to agriculture and also threaten the few native, natural ecosystems we have left. For example, purple loosestrife, *Lythrum salacaria,* is overtaking our marshy habitats in the north, and Japanese honeysuckle, *Lonicera japonica,* is outcompeting the understory in the south. Concentrated efforts by concerned citizens and public agencies are needed to reduce the threat from exotics.

Although ambitious, ILPIN has only begun to organize the information avail-



Number of Endangered/Threatened Species Recorded per County

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able for the species, nor is enough known about most of the species to complete all the variables. Data entry is completed presently for distribution data, common names, synonyms, taxonomic hierarchy, taxonomic characteristics, and natural community preferences. The ILPIN data base resides on INFO data base management software which provides user friendly environment for data extractions of vast amounts of information on the species. It is linked also to the Illinois Geographic Information System (GIS) which allows generation of maps as another type of output. The work is being supported by the Survey and the Illinois Department of Transportation. The data will be available eventually for other agencies, researchers, schools, scholars, and the public to access for information pertaining to the plants of Illinois.

Recent Survey Publications

The production and growth of F_1 hybrid crappie. D. Homer Buck and Michael Hooe. Biological Notes No. 125. February 1986. 8 pp.

A directory of Illinois systematists and ecologists. Kenneth R. Robertson, Philip J. Burton, and Bill N. McKnight. Special Publication 3. April 1986. 102 pp.

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NATURAL HISTORY SURVEY REPORTS

APRIL 1986, NO. 256

)emographic Parameters of Fox Squirrels

Nearly 70 percent of the squirrels har-
ested by hunters each fall in Illinois are
ox squirrels, and squirrel hunting is one
f the most popular recreational uses of
he public parks and forests in this state.
Hunting pressures on squirrels are in-
reasing on public forests, and managers of
quirrel populations need information con-
erning the population dynamics of fox
quirrels to protect them from excessive
arvest levels while providing hunters with
n opportunity to pursue their sport.

With funds provided by the Illinois De-
artment of Conservation, wildlife ecolo-
ists Charles Nixon, Lonnie Hansen, and
Steve Havera have recently completed a
7-year study of a fox squirrel population
rotected from hunting. One objective of
he study was to determine population
egulation in this species in the absence of
unting. A knowledge of how population
evels are maintained in the absence of
hunting can provide clues as to how
squirrel populations recover from hunting
osses and the limits of their ability to
lo so.

Recruitment (the number of new squir-
rels that enter and remain at least 6
nonths) depended upon both immigration
nd on production of young by resident
emales. Recruitment success for immi-
grants was best for adults and yearlings
nd poorest for subadults. Breeding success
of adult females was highest in winter and
was affected negatively (lower breeding
rate) by the number of females conceiving
the previous breeding period. Breeding
rates for yearling females, recruitment suc-
cess of immigrants and of young born on

The fox squirrel carries a nut to its nest in an area where a 7-year study was conducted of a fox squirrel population protected from hunting (Photo by Les Woodrum).

the area, and overall changes in squirrel densities between trapping periods were affected negatively (lower values) by numbers of adult females.

In most years, adult females were dispersed evenly throughout the forest whereas adult males and young showed an aggregated or random dispersion. These patterns of dispersion for fox squirrels mean that adult females avoid each other while adult males and young are more tolerant of other squirrels. The number of young produced on the study area each year was not related significantly to population change.

During the 7-year study, tree seed crops, which constitute the principal diet of these squirrels, were relatively abundant and had no significant effect on recruitment success, number of conceptions, sur-

vival of resident squirrels, or overall changes in densities.

In summary, without obvious environmental stresses, such as a food failure or high harvests by hunters, fox squirrels appear to stabilize their numbers through aggressive interactions between adult females and resident young and immigrants of all ages. Studies where adult females are periodically removed, thus simulating a hunting situation, have shown increased recruitment of immigrants, particularly females, further indicating the role that adult females play in controlling changes in population densities. Apparently when hunters removed these dominant adult females each fall, they allow a nearly always abundant immigrant population to move into the hunted forests and thus replace those squirrels shot each year. On most public forests, there is a portion of the area that is protected from hunting because alternative recreational uses (picnic sites, camping areas, natural areas, etc.) attract and provide squirrels to immigrate onto the hunted forests.

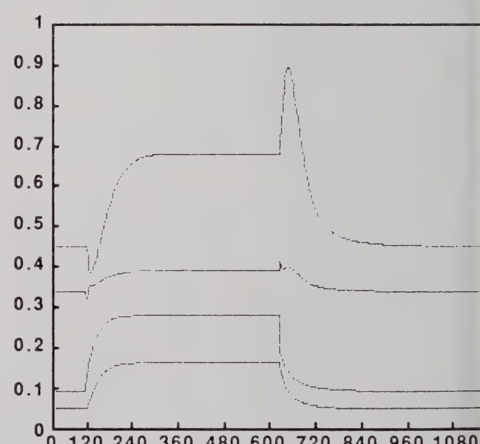
The Eco/Eco Systems Analysis Project

The Ecological and Economic Systems Analysis Project (Eco/Eco) has as its long-term goal the incorporation of ecological criteria, constraints, and principles into economic analysis and planning. The project hopes to go beyond a "laundry list" approach that merely catalogs a number of disparate effects and rely instead on such broad concepts as ecosystem health and resilence. The end product of this approach will be planning guidelines for ecologically sound economic development of the State of Illinois.

This goal, the ultimate goal of applied ecology, has been sought by other research groups, but in each case the synthesis has been based on incomplete hypotheses and limited or no experimental verification. In an attempt to eliminate this deficiency, Survey researchers have set a short-term goal of experimentally testing principles related to the behavior of ecosystems under the economics-like constraints of resource scarcity and varying cropping. The hypothesis is that using principles based on economics permits a more accurate prediction of numbers of organisms and concen tration of nonliving components (collec tively called "compartments") than d the more usual deterministic approache

In the past year, Robert Herendeen an Randall Hicks have refined this theor and designed experimental tests. They hav incorporated techniques from Dynamic In put-Output Economics in order to develo energy intensities for time-varying eco systems; previously such intensities hav been calculated only for steady state Energy intensity is a systemwide quantit that expresses the interdependency amon the components of an ecosystem; it is, fo example, the solar energy required directl and indirectly to produce one unit of com partment X's output. Energy intensity i compellingly similar to "price" in economi systems.

Among the hypotheses to be tested i whether or not the numbers of organism in an ecosystem are more reliably predicte when an optimizing principle is used (e.g that the system is maximizing the sum o each compartment's output weighted ac cording to its energy intensity). A conse quence of such optimization might be tha certain organisms do not produce nev biomass to their full potential; if they did they might, for example, overgraze an ultimately destroy the system. To tes this hypothesis we begin with laborator microcosms that contain relatively simple



Twelve hundred-day simulation for a two-lev ecosystem subject to a doubling of incident light be tween years 100 and 600. The lowest two traces sho numbers of organisms for autotrophs and herbivore The uppermost two traces show energy intensitie Units on the y-axis are arbitrary.

constructed aquatic ecosystems (e.g., phytoplankton, herbivores, bacteria, plus approximately four nonliving components). Differences between competing hypotheses will become apparent only in dynamic response to time-varying light and cropping, not at steady state. Compartment stocks and intercompartment flows must both be measured frequently during times of change. The most dramatic differences between optimizing and deterministic behavior take place when resource scarcity occurs suddenly, as for example, when light is abruptly reduced.

This specific study is embedded in a broader program designed to improve our understanding of the dynamics of nutrient and energy flow in ecosystems. Two additional topics under study are (1) cycling indices, which quantify how long nutrients or energy reside in an ecosystem, and (2) the importance of specific microbial activities in aquaculture and in selected habitats of the Mississippi River.

The Fly Agaric Mushroom

Among the most beautiful yet poisonous mushrooms of our woodlands is the Fly Agaric, *Amanita muscaria.* It is abundantly distributed in coniferous wood in Illinois and is also known to have a worldwide distribution.

This fungus consists of a network of filamentous cells termed mycelium, and a reproductive structure called the mushroom. The relationship of the mushroom to the mycelium is analogous to that of an apple to the apple tree. The mycelium of the Fly Agaric forms mycorrhizal associations with woodland trees. That is, the hyphae of the mycelium form a symbiosis with the roots of trees; both fungus and tree deriving benefit from the association.

The Fly Agaric is distinguished by a yellowish cup at the base of the stalk (a remnant of a membrane which enveloped the young fruit body), a ring on the stalk, free gills of unequal length, white spores, and a fiery red, scarlet to orange or yellow, hemispherical to expanded cap. The cap is sticky when moist and shiny when dry, and covered with white and yellow scabs which are easily deciduous and usually arranged in concentric circles.

The beautiful, but deadly, Fly Agaric mushroom *(Amanita muscari)* found in many areas of Illinois.

Because of its beauty, this mushroom has been illustrated in numerous herbal and botanical works and is frequently photographed. In folklore it is called the "good luck mushroom" and it has been used for both recreational and religious activities in Europe.

Consumption of the Fly Agaric, however, is not without danger for this mushroom contains the following four powerful toxins: muscarine, ibotenic acid, muscinol, and muscazone. This appropriately named *Amanita* attracts flies and kills them due to the conversion of obotenic acid to muscinol, an insecticide. The toxin muscarine is named for the species *Amanita muscaria,* from which it was isolated in 1869. This toxin has been isolated subsequently from certain species of *Clitocybe* and *Inocybe.* It causes blurred vision, sweating, labored breathing, increased peristalsis, reduced heart rate and blood pressure, and in severe cases, convulsions. The major effect of eating the Fly Agaric is now known to be due to ibotenic acid and muscinol in this country, and musca-

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zone which is found only in the European specimens. These toxins are neurological, especially acting on the cerebral nervous system. The symptoms include inebriation, distortion of senses, manic behavior, delirium, deep sleep, and visions. For example, small objects seem large, and spatial perception changes like parts of Alice's trip to Wonderland. The Vikings reportedly ate *A. muscaria* before battle; they attained the feeling of invincibility and frequently went into battle without shields.

The North American specimens of *A. muscaria* do not appear to have the mind-expanding properties noted in the European collections. The North American symptoms are dilated pupils, a period of uncoordination, and rapid heart beat.

The Fly Agaric is representative of many beautiful yet poisonous mushrooms. Much remains to be learned about poisonous mushrooms and their toxins, as the chemical composition of most mushroom species is unknown and reports on edibility are not available for many species. Careful collecting, accurate identification, and moderate eating are the best defenses against mushroom poisoning.

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NATURAL HISTORY SURVEY REPORTS

MAY 1986. NO. 257

Slow Growth and Short Life Spans of Illinois River Carp

Common carp, *Cyprinus carpio,* are an important commercial resource of the Illinois and Mississippi rivers. In 1953 and 1954, commercial catches between 2 and 3 million pounds, valued then at around $250,000, were taken from both rivers. Since then, however, annual catches from the Illinois River have been poor, ranging between 103,000 and 361,000 pounds between 1970 and 1982. Scientific collections have indicated that carp are actually more abundant in the Illinois River than the Mississippi, but that on the average they are 114 mm (4.5 in.) shorter. Commercial fishermen and river biologists have associated much of the post-1950's decline in Illinois River commercial harvests with the lack of large carp.

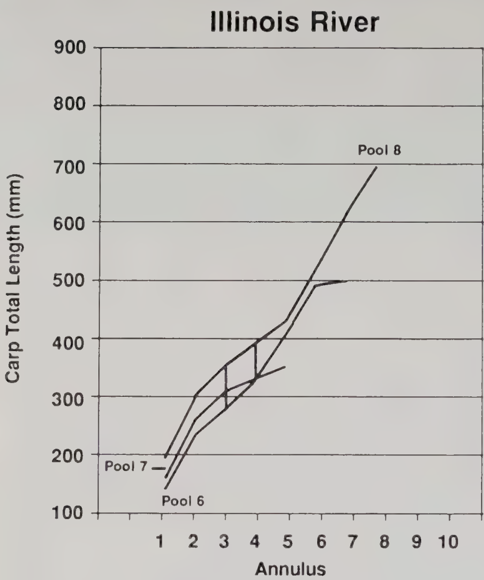
Over the past 3 years, Survey biologists Scott Jackson and Jim Cassens, at the Pool 26-River Research Lab near the confluence of the rivers, collected and aged carp to determine if Illinois River stocks are growing more slowly or living shorter lives than their Mississippi River counterparts. Both phenomena were confirmed. Ken Lubinski directed the study which was supported by funds from the National Science Foundation, the National Marine Fisheries Service, and the Illinois Department of Conservation, Project No. 3-383-R.

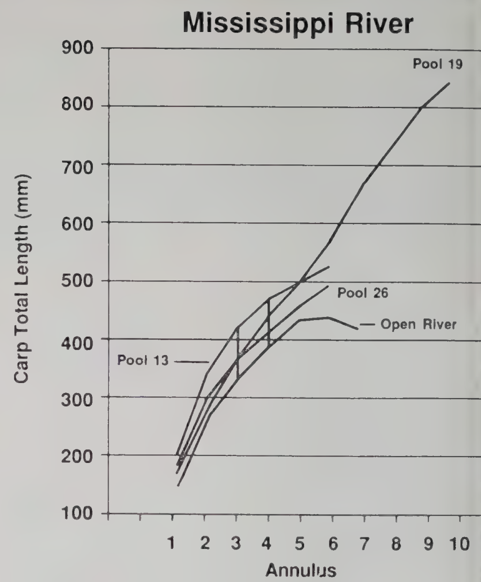
Specimens were collected from several navigation pools of both rivers and the open river reach (i.e., without dams) of the Mississippi River. Electrofishing collections yielded 758 carp and an additional 423 specimen were measured and aged at local fish markets. Scale annuli (annual growth rings present on scales) were used to determine carp ages, and annual growth rates were determined by back calculating total lengths of carp at respective ages.

Illinois River carp had much shorter life spans than Mississippi River carp. Collections from the middle Illinois River (i.e., the Peoria and La Grange navigation pools) were dominated by 3-year-old fish and only 2 of the 343 fish collected were more than 4 years old. The oldest carp taken from the Illinois River was 8 years old. In contrast, carp stocks in Mississippi River navigation pools were dominated by 4-year-old fish, age classes between 5 and 8 were well represented and the maximum age observed was 10 years. In general, percentages of older fish increased in the downstream direction on the Mississippi River.

Illinois River carp also grew more slowly than Mississippi River carp. As an example, back-calculated total lengths of carp at age 4 from the middle Illinois River were between 332 and 334 mm (approximately 13.1 in.). Mississippi River carp at age 4, in contrast, ranged between 389 and 470 mm (15.3-18.5 in.) in total length. As with percentages of older individuals, carp growth rates increased in the downstream direction on the Illinois River and in the upstream direction on the Mississippi River.

Considerable evidence exists to support a hypothesis that carp age and growth problems on the Illinois River are due to a lack of quality food items in their diet. In the 1950's, a dramatic die-off of fingernail clams, mayfly larvae, and other benthic macroinvertebrates occurred in the Illinois River. This die-off, generally attributed to





Total lengths of annuli of carp in the Illinois and Mississippi rivers.

a pollution complex, was most severe in the middle Illinois River, above the mouth of the Sangamon River. Recent surveys have shown that benthic macroinvertebrates are still scarce in this river reach. Interspecific competition and poor habitat quality may also contribute to the problem.

The combined studies on the Illinois River demonstrate how depletion of species that otherwise might be considered unimportant can have devastating impacts on well-known, and in this case, commercially valuable species. The near future outlook for the middle Illinois River is not good. Although river water quality has been improving, improvements in sediment quality have lagged behind. River biologists suspect that natural, self-cleaning mechanisms for river sediment may require considerably longer periods of time.

Welcome Ladybird

Foreign insect pests that are inadvertently imported into North America commonly arrive unaccompanied by the pathogens, parasites, and predators that control their numbers in their places of origin. One tactic used by economic entomologists to suppress exotic pest species is the introduction of certain of their natural enemies. This is a form of biological control.

In 1956, the United States Department of Agriculture began the first of a series of attempts to introduce a Eurasian ladybird beetle, *Coccinella septempunctata* L., "C-7", for short, for the control of pest species of aphids — both native and introduced — on various crops. C-7 is a voracious predator of aphids in both the larval and adult stages. The adult C-7 is about three-eights of an inch in length and has

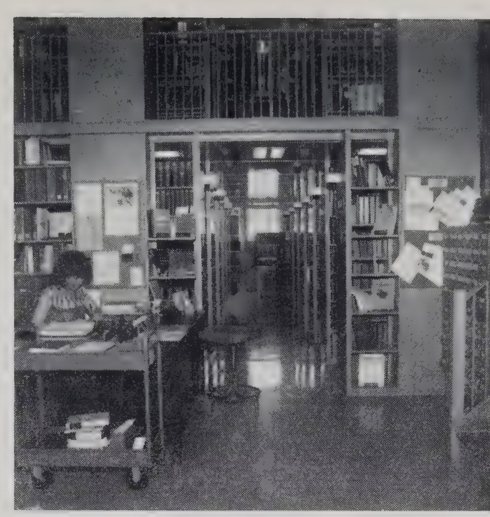
Ladybird beetle, *Coccinella septempunctata L.* (drawing by John P. Sherrod).

seven well-defined black spots on red wing covers.

Entomologists William Luckmann and Clarence White of the Survey collaborated with USDA scientists in attempts to establish C-7 in Illinois. During 1975-1978, they released 40,000 adult beetles at several sites in the vicinity of Champaign. The beetles released were from a New Jersey population near Kennedy International Airport where C-7 seems to have been accidentally introduced sometime prior to 1974. While the Illinois releases and many other releases in the United States seemed unsuccessful, the New Jersey population is spreading across the northern United States.

The beetle was first detected in Illinois in late August of 1985 near Momence in Kankakee County by Survey entomologists John Bouseman and Bill Ruesink. They and other entomologists have added Will, Grundy, Iroquois, Vermilion, Champaign, Moultrie, and Fayette counties to the known distribution of C-7 in Illinois durin the fall of 1985. Entomologists of the Illinois Natural History Survey, the Illinois Department of Agriculture, and the United States Department of Agriculture will be monitoring the further spread of C-7 in Illinois during 1986 and subsequent years.

If readers of the *INHS Reports* find a beetle they believe to be C-7 from Illinois counties other than those mentioned above, they may be sent in alcohol to John Bouseman, Section of Economic Entomology, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, Illinois, 61820, for confirmation.



Survey Librarian Carla Heister sits at the desk near the entrance of the Library (photo by Les Woodrum).

The Library in the Information Age

Information is useful only if it can be retrieved. That is the basic premise for existence of the Natural History Survey Library information retrieval. The library is not only a storehouse for books, it is an integral part of research as it is conducted at the Survey. Past, present, and future, the Library has had and will have a continuing commitment to providing information services to its patrons.

When the library moved to its present location in 1950, information was accessible in paper form, from the card catalog to indexing and abstracting tools such as Biological Abstracts to the journals and books containing the needed data/information. The technological advances of the 1960's and 1970's brought about an information explosion as never seen before. Just as the Industrial Revolution changed the agrarian society to an industrial society, the Information Explosion of post-World War II is changing the industrial society to an information society.

In the past, finding information on a subject was very time consuming. Manually searching indexes, abstracts, bibliographies, and card catalogs took hours, days, or weeks of valuable research time. The library helped in getting the needed literature searching completed efficiently, but not quickly. There was no one place to go for everything needed.

As the new technologies for computerization advanced, libraries found information storage and retrieval systems that could be used in many different aspects of library work. The catchwords, online, electronic data, and data base entered the vocabulary of the librarian. The development of interactive online cataloging, the online catalog, electronic mail, electronic data processing, electronic journals, and bibliographic, numerical, and full text data bases have caused major changes in library operations.

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The Survey Library has entered the mainstream of this electronic revolution. The advantage of being affiliated with the University of Illinois Library as well as being an agency library of the Illinois Department of Energy and Natural Resources has provided sources of advancement in the handling of information.

Through the University, the Survey Library has gained access to over 200 bibliographic, numeric, and full text data bases for online searching to retrieve citations and other pertinent information on a subject. The University Library card catalog, and therefore the Survey Library card catalog, is now computerized and available online to any patron with a computer terminal and modem. The Library now houses a microcomputer which is used for online searching, word processing, data management, bibliographies, and circulation functions.

Information gathering techniques have changed in the 128-year history of the Natural History Survey Library, but the commitment to service is stronger than ever, according to Librarian Carla Heister and her assistant, Monica Lusk. The Library is here to aid in information gathering and that will never be outdated.

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